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(Authors alone are responsible for the opinions and facts stated in their respective Papers.)

LONDON.

1902.

ILLUSTRATIONS.

PLATES.

FIGURES IN THE TEXT.

ILLUSTRATIONS.

PLATES.

FIGURES IN THE TEXT.

LIST OF LECTURES, 1901-1902.

LIST OF PAPERS READ, 1901-1902.

ADDENDA ET CORRIGENDA.

Page 135, line 12, *for* "Report by H. W. MONCKTON" *read* "Report by A. S. KENNARD."

" 148, line 36, *for* "uncomfortably" *read* "unconformably."

" 166, line 36, *for* "to the peculiarly shaped valley" *read* "to some peculiar lines along the valley."

" 174, line 4, *for* "Mr. L. Holmes" *read* "Mr. T. V. Holmes."

" 215, line 43, *for* "As we have already seen" *read* "As we shall presently see."

" 237, fig. 35, *for* "*Carychima*" *read* "*Carychium.*"

" 242, line 14, *for* "recorded from" *read* "recorded previously from."

" 243, line 33, *after* "*Hydrobia snbumbilicata*" *insert* "(in Mr. Bell's list)"

" 251, line 15, *for* "It may prove to be" *read* "It is probably."

" 252, line 20, *for* "139" *read* "138."

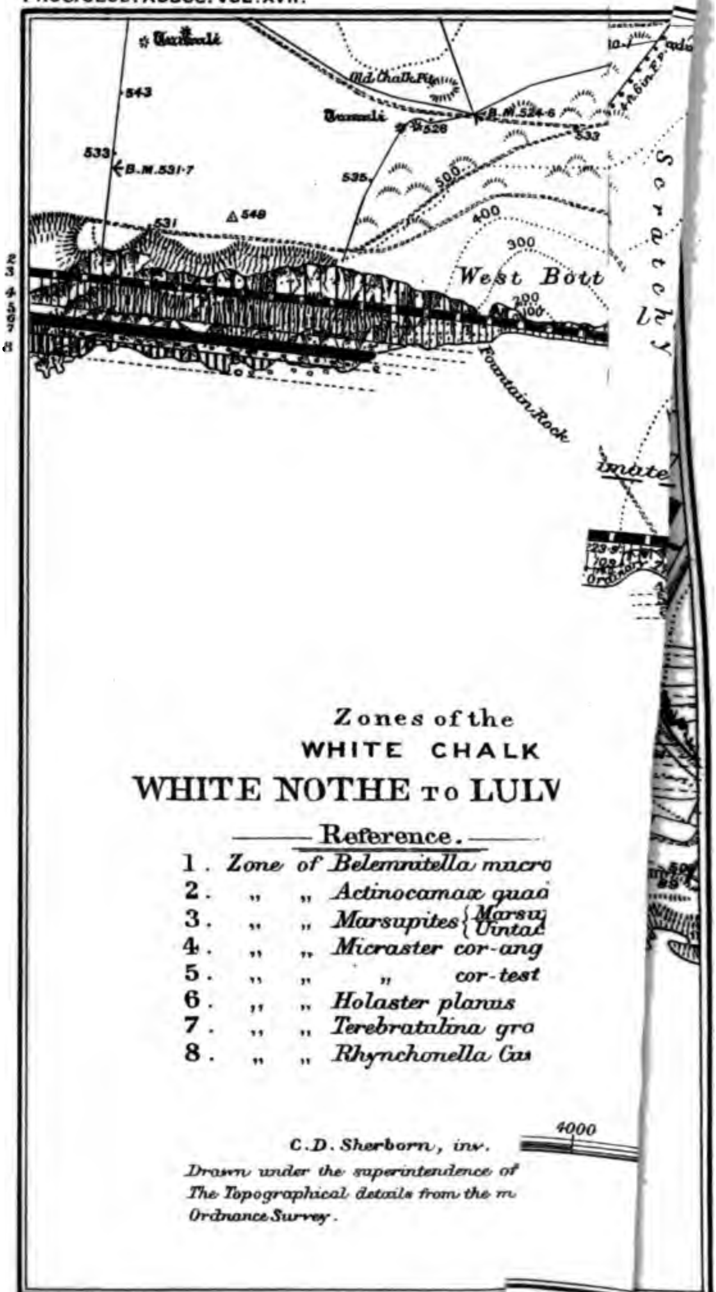
" 257, line 13, *for* "two last" *read* "last two."

" 371, line 11, *for* "*junatum*" *read* "*funatum.*"

" " line 25, *after* "remanié" *omit the comma.*

" 383, lines 28 and 36, *for* "Headingley" *read* "Headington."

" 410, line 22, *for* "portions" *read* "positions."


Old Chalk Pit
B.M. 531·7
B.M. 524·6
543
533
535
531
528
533
△ 549
500
400
300
200
100
West Bott
Fountain Rock
Scratchy
2
3
4
5
6
7
8
Zones of the
WHITE CHALK
WHITE NOTHE to LULV
Reference.
1. Zone of Belemnitella macro
2. " " Actinocamax quad
3. " " Marsupites { Marsu / Uintac
4. " " Micraster cor-ang
5. " " " cor-test
6. " " Holaster planus
7. " " Terebratulina gra
8. " " Rhynchonella Cus
4000
C. D. Sherborn, inv.
Drawn under the superintendence of
The Topographical details from the
Ordnance Survey.

R.G.S. lith.

THE ZONES OF THE WHITE CHALK OF THE ENGLISH COAST.

BY DR. ARTHUR W. ROWE, F.G.S.

II.—DORSET.

THE MAPS AND CLIFF-SECTIONS.

BY C. DAVIES SHERBORN.

[PLATES I—X.]

(Read December 7th, 1900.)

THE WHITE CHALK OF THE DORSET COAST.

FROM WHITE NOTHE TO WORBARROW BAY, AND FROM BALLARD HOLE TO STUDLAND BAY.

CONTENTS.

INTRODUCTION.

IT is difficult to say which most compels one's admiration, th marvellous beauty of this boldly-sculptured coast or th power and magnitude of the physical forces which have deter mined a coast-line possessing, in point of interest, variety, an strength of contrast, no parallel among sections of the Englis Chalk.

Look where one will, the influence of the great Isle c Purbeck fault is felt. It dominates everything. Instead of bed dipping at a gentle angle, as we have seen in Kent and Susse we here find them either sharply inclined, vertical or inverted The consequence is that a single bay will take us, in one bold sweep from the Portland Stone right up to the higher beds of the Whit Chalk. But, while this affords a fine field for observation for th physical geologist, it brings with it a proportionate degree c difficulty to the zoologist, for the beds are compressed, slicken sided, and veined with calcite to such an extent that th collector has but a poor chance of making a respectable list c fossils. Moreover, the specimens obtained are frequentl shattered, and so loosely re-cemented that, when removed fron the cliff, they fall in pieces. There is great difficulty i cleaning such fossils, and even the dental-engine is powerles to develop them; we have to be content with the weathere surface already exposed. It is small wonder, then, that ou table of fossils is but meagre.

The flints give an excellent idea of the amount of crushin that has taken place, for they are often shattered into hundreds c fragments, and sometimes the fracturing has been so great as t reduce them to a long-drawn-out line resembling coal dust. Thi is noted by Mr. Strahan in the Survey Memoir on this coas Unlike those in the Isle of Wight, the flints on this coast are nc re-cemented.

As in the first paper of this series (Kent and Sussex),* w shall confine our attention almost entirely to the zoology of th beds under consideration. The physical features of this distric have been so lucidly and graphically handled by Mr. Strahan i the Survey Memoir that there is no need, even if we so desirec to go outside the scope of our work to repeat in detail thes observations. For zoological data the reader is referred to Di Barrois' classical work.† The results of our collecting cause us t differ from him in several important particulars, but as we followe up this difficult coast we could not but admire his broad grasp c the subject, and the general accuracy of his conclusions.

Mr. Strahan mentions the fact that the degree of crushin

* *Proc. Geol. Assoc.*, vol. xvi (Part 6), 1900.
† "Recherches sur le terrain crétacé supérieure de l'Angleterre et d'Irlande," Lille, 1876.

increases as we pass west, and that the maximum compression is to be seen in the little headland separating St. Oswald's Bay from Man-o'-War Cove. Here beds, which should be 1,000 ft. thick, measure only 250 ft., and it is seen that, from the *Holaster planus*-zone at the base of the promontory to the Man-o'-War Rock (Portland Stone), we have to crowd in the remaining beds of the White Chalk, the Grey Chalk, the Greensand and Gault, and the Wealden and Purbeck series. All this has been compressed into about 90 yards. Mr. Strahan's detailed information of the beds below the Chalk enables him to state that not only has great compression existed, but that certain beds have actually been squeezed out, *e.g.*, that the Upper Purbeck strata are squeezed out at Durdle Door and the Lower Purbeck division at Dungy Head. His explanation is that parts of the mass have been caused by the compression to slide over one another along a number of different bedding-planes, rather than along a definite line of fracture.

This compression to a large extent robs the zones of their characteristic lithological features, and reduces them to a more uniform appearance. But for the zoological evidence we should have a poor chance of determining zonal boundaries. On this coast, even to a greater degree than elsewhere, we see the value of rigid zonal collecting, for without such data the result would be pure inference and guess-work. The various flint-containing beds are so slickensided and veined with calcite that they are incapable of being separated from one another by mere inspection, unless they are persistently darkened by iron or marl. As an example of hardening, we mention that the chalk of the zone of *Belemnitella mucronata*, obtained along the line of the vertical beds of the Chalk Ridge, is so hard that we can trim it with a hammer like a flint, whereas that from the horizontal beds at Wool is so soft that one can crush it between the fingers.

From a point half way between White Nothe and Bat's Head to Worbarrow Tout we can trace the protecting barrier of Portland Stone, sometimes as the solid rampart of the coast, and at others as reefs and rocks. These rocks serve a useful purpose, in that they afford a datum-line from which we can fill in the beds which have been destroyed. In connection with this point it may be well to mention that, in the Chalk area, each little bay is a copy of the other. In the case of Lulworth Cove we have a perfect and symmetrical example, for the bay is almost circular, and the breach through the Portland Stone barrier surprisingly narrow. Once the barrier is breached, either by the waves, or by the outflow of a stream, the task of destruction is easy, for the crushed and crumpled Purbeck and the soft Wealden readily wash out, and so the process of erosion goes on till some more compact bed stops the progress. In the case of Lulworth Cove the head of the bay is formed by the hard *Rhynchonella cuvieri*-zone. Other bays, owing to uneven wasting by the sea, do not

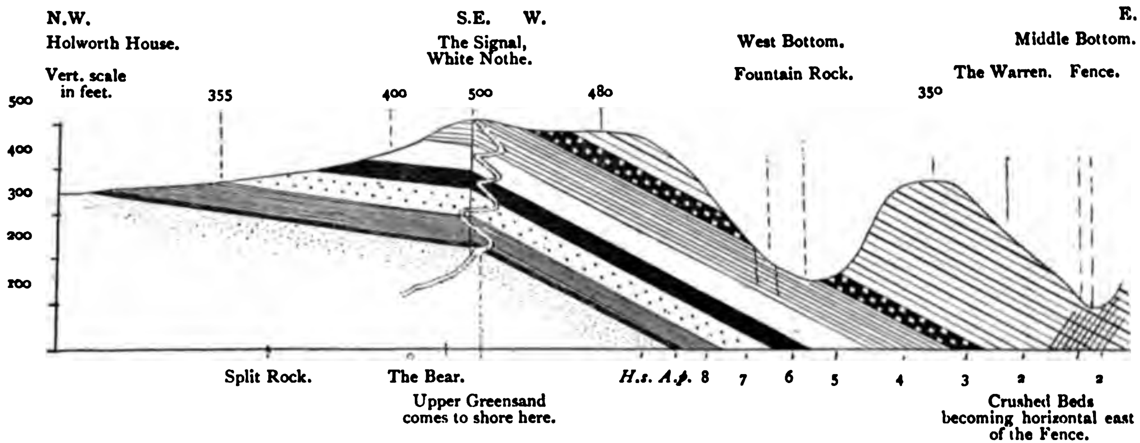


FIG. 1.—CLIFF SECTION FROM HOLWORTH HOUSE TO WHITE NOTHE AND THENCE TO MIDDLE BOTTOM.

REFERENCE TO ZONES.

2. Zone of *Actinocamax quadratus*.
3. " *Marsupites* { *Marsupites*-band. / *Uintacrinus*-band.
4. " *Micraster cor-anguinum*.
5. *Micraster cor-testudinarium*.
6. Zone of *Holaster planus*.
7. " *Terebratulina gracilis*.
8. " *Rhynchonella cuvieri*.
A.p. " *Actinocamax plenus*.
H.s. " *Holaster subglobosus*.

Length of section = 2 miles.

exhibit a complete repetition of the strata at their two ends. This is seen at Durdle Bay, Man-o'-War Cove, St. Oswald's Bay, and Mupe Bay.

It is obvious, then, that in whatever rock the horns of a bay may be cut, as we pass along one side of the bay we continually traverse the surfaces of higher and higher zones, until we reach the zone in which the head of the bay is formed. In completing the circuit of the bay, we pass over the same beds in reversed order.

Within the area of the great fault it is interesting to note that all the little headlands are faced in hard rock. Bat's Head, Black Rock, Cover Hole, and Ballard Point are faced with chalk of the zone of *Holaster planus*, Man-o'-War Point with that of the *Rhynchonella cuvieri*-zone, while Durdle Door, the promontory lying between Dungy Head and Mupe Ledges, and Worbarrow Tout, are all protected by Portland Stone.

This coast-section is so disconnected that there is no necessity for following up the beds in one continuous line, irrespective of their natural sequence, as in the case of the cliffs of Kent and Sussex. We shall begin from the west, as the beds are there horizontal, and the sequence of the lower zones is well displayed.

For the convenience of those who wish to work this coast we give some local information. The only places to make one's headquarters are either West Lulworth or, better, Lulworth Cove. Accommodation is small, and the visitor should never go down in the summer on the chance of getting rooms. Wool station is six miles from Lulworth Cove.

White Nothe to Bat's Head.

The White Nothe section is best divided into two parts: that at the top of the cliff and at the undercliff, and that on the shore.

(1) THE UNDERCLIFF.

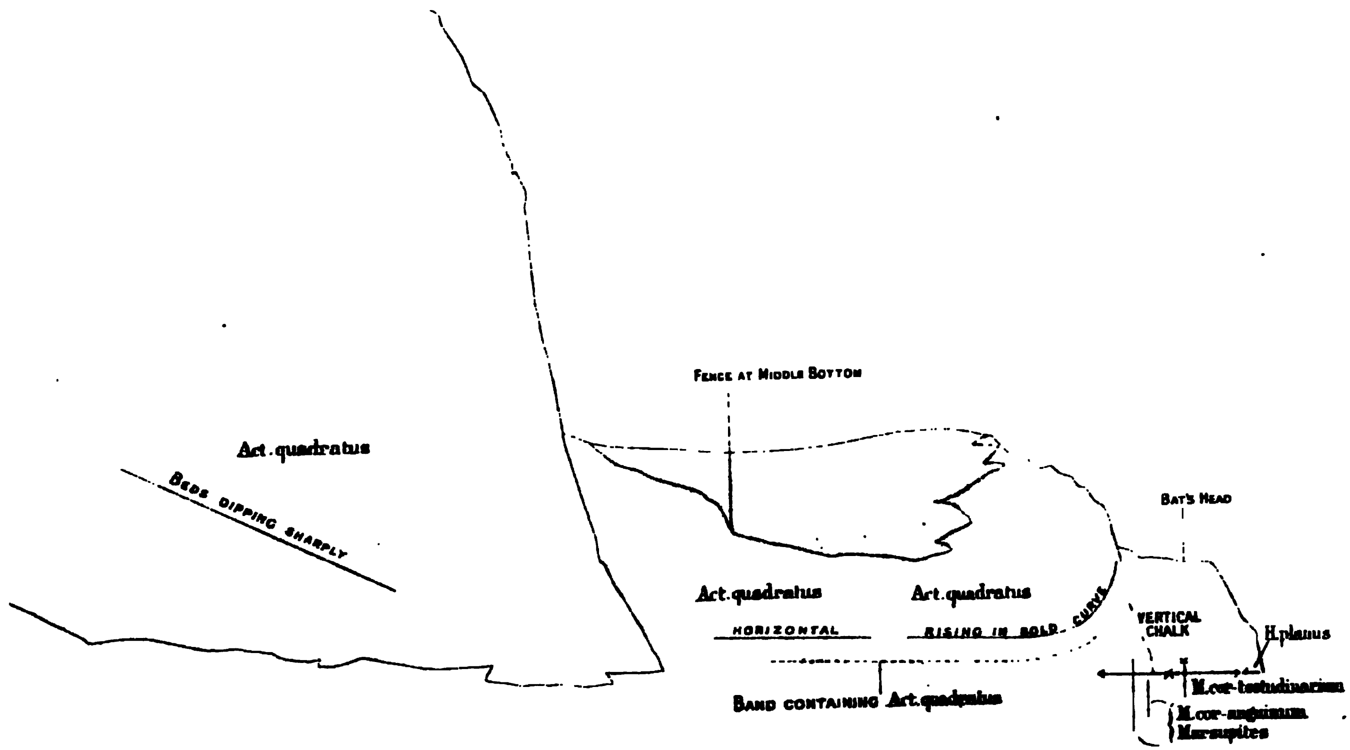
This section is best reached by road, though by taking boat to the west of White Nothe one can climb to the Undercliff. It can be reached, immediately below the signal, by climbing up the talus, but the ascent is difficult and not worth the labour. The quickest way to get there from Lulworth is to strike up the valley, north of Hanbury Tout, to Newlands Farm, and pass through the gate on the immediate north of the house. This leads across the fields to the coastguard track, which one can easily find by following the telegraph poles. This path takes us straight to White Nothe. There is a zig-zag path, which is perfectly safe, down the cliff. The descent to the zig-zag is in front of the signal. We pass westward along the Undercliff for nearly half-a-mile, when we come to a fine section from the Upper Greensand to the zone of *Rhynchonella cuvieri*, all the beds being beyond the range of the great fault, and therefore nearly horizontal The blocky chalk of the *Holaster subglobosus*-zone weathers out finely, and the narrow bands of the Chloritic Marl and *Actinocamax plenus*-zone are clearly defined. There is a full day's work to be done in collecting on the Undercliff. Excellent collecting, especially from the Chloritic Marl, may be done from the fallen blocks at the foot of the talus

We now retrace our steps towards the signal bluff, and find several finely weathered fallen masses. We first examine a very clean exposure of *Rhynchonella cuvieri* chalk, situated under the 30 oft. contour-line on Sheet LIV, N.E., of the 6-in. map. Fossils are characteristic, but by no means abundant. We next reach a long grey mass, looking like a ruin, with its long axis running east and west. This is clearly in the zone of *Holaster planus*, as the name-fossil is not uncommon, and *Micraster*, of the form characteristic of this bed, is abundant. South of this we see the King Rock, which is cut in the zone of *Holaster subglobosus*, and based in Greensand. Then follow some cleanly weathered masses in the *Rhynchonella cuvieri*-zone, poor in fossils as usual. Nearer the signal bluff are two more slipped faces, one in the zone of *Holaster planus*, and the other in the base of the *Micraster cor-anguinum*-zone. No fallen masses could be assigned to the zones of *Terebratulina gracilis*, *Micraster cor-testudinarium*, or *Marsupites testudinarius*.

As we pass eastward from the main section, we note that the zone of *Terebratulina gracilis* soon appears at the top of the cliff, and later on that the *Holaster planus*-zone comes in. Immediately west of the signal bluff is a fine face of *Holaster planus*-chalk, with a steep talus leading to it. It was well worth the climb to reach this, as the surface was magnificently weathered, the fossils, especially *Micraster*, being so thoroughly exposed that in many instances there was only a small pedicle of chalk to attach them to the cliff. This bluff was rich in *Holaster planus*, *Terebratula carnea*, *Pentacrinus*, and all the characteristic fossils of this zone; it was evident that it had not been desecrated by a hammer for many years.

The signal bluff itself is based in the zone of *Holaster planus*, though we did not find the name-fossil. It was this bluff, and the one last described, which were mentioned in the Kent and Sussex paper (*op. cit.* p. 314) to exemplify the uncertain occurrence of *Holaster planus* in its own zone.

As we ascend the zig-zag we pass over the zones of *Micraster cor-testudinarium* and *Micraster cor-anguinum*. Barrois assigns the top of the cliff, about 30 ft. below the signal-house, to the zone of *Marsupites testudinarius*, for the reason that the flints are similar in appearance to those found in that zone. He did not find *Marsupites*, nor were we any more successful, for at the time of our visit it was blowing half a gale, and



BAY BETWEEN WHITE NOTHE AND BAT'S HEAD.

Pl. I.

the climb was too risky. An examination of other small and accessible faces revealed no evidence of a *Marsupites*-fauna. However, at the top of the cliff, in a slipped face, 100 yds. east of the signal, we found a complete series of guide-fossils to this zone, *Marsupites*- and *Uintacrinus*-plates in their proper relative position, *Echinocorys vulgaris* var. *pyramidatus*, the nipple-shaped head of *Bourgueticrinus*, and ten examples of *Terebratulina rowei*. We tried to find evidence of an *Actinocamax quadratus* fauna, but failed. We were unable to obtain any measurements in this situation. This chalk, though horizontal, is sufficiently near the area of the fault to be greatly altered, and it is in consequence very difficult to clean the fossils from it.

(2) ON THE SHORE.

This section can be best reached by means of a boat. Having landed below the signal one can examine the whole of the section under White Nothe at low tide, as far as the big sloping ledge in the *Terebratulina gracilis*-zone, just after we pass the Chalk Rock of the Geological Survey in the cliff. If the tide is really low we can climb over the ledge; if not, we must use the boat again. From here to Bat's Head there is a shingle beach, and most of the cliff can be worked at high tide, provided there are no spring tides, and the wind is not blowing strongly from the sea. On the talus, between the undercliff and high-water-mark, are many fine fallen blocks. Those from the *Holaster planus*- and *Micraster cor-testudinarium*-zones are particularly rich in fossils, and can readily be zoned by the aid of *Micraster*.

This is a very fine section, for between a point corresponding with the signal and Middle Bottom we have a flat bay which takes us up from the Greensand to the zone of *Actinocamax quadratus*. At first the beds are practically horizontal, but they soon begin to dip at about 8°, and by the time we reach the Fountain Rock they are falling rapidly, and form the western side of a syncline. The trough curves down sharply till we near Middle Bottom, where the beds are horizontal, and remain so for about 100 yards. They then gently rise until nearly half-way between Middle Bottom and Bat's Head, where they sweep up in a bold curve, which strongly reminds one of the line of fault at Ballard Head, save for the fact that the curved beds do not lie against vertical chalk. The maximum curve occurs about 400 yards west of Bat's Head. A little east of this the beds become vertical, and Bat's Head itself gives one of the cleanest sections of vertical chalk on the coast.

It is difficult to fix the line of exit of the Isle of Purbeck fault. One view is that it may occur west of Bat's Head, where the beds sweep up in a bold curve; another is that it takes place in the shattered chalk east of Middle Bottom, as indicated on Mr. Strahan's section; and a third is that it may be found in the recess at Middle Bottom, where the chalk is shattered in every direction. We incline to the last-mentioned view. In any case, if the fault runs out seawards at all near this point, there is nowhere any definite line of fracture. In fact, from Middle Bottom to the point where the sharp upward curve takes place, west of Bat's Head, the beds are shattered and slipped in every direction, so that it would be very difficult to fix the exit of the fault correctly. (Pl. I.)

The headland at White Nothe is cut in the zone of *Holaster subglobosus*, the alternate hard and soft layers of which cause the foot of the headland to have a strikingly sculptured appearance. We pass over a finely-exposed section of *Actinocamax plenus*-marls, and then come to the White Chalk.

Zone of Rhynchonella cuvieri.

The junction of the *Actinocamax plenus*-marls with the zone of *Rhynchonella cuvieri* is very obvious, and we carry this zone up to the first line of flints, which appears in a little bay 40 yards west of the big sea-washed ledge in the *Terebratulina gracilis*-zone. The *Rhynchonella cuvieri*-zone is very hard and nodular, and it contains pyrites and an occasional marl-band. It is washed by heavy seas, and fossils are rare, though quite characteristic. Thickness of zone, 76 ft.

Zone of Terebratulina gracilis.

When we pass the above-mentioned flint-band, the chalk becomes less nodular, marly bands are commoner, and organic remains more abundant. *Terebratulina gracilis* itself, though never common, can always be found. A little west of the strong projecting ledge before mentioned in this zone, 5 ft. up in the cliff, we see bands, some 5 ft. in thickness, of yellow-green nodules. This is apparently the nodular material which has been alluded to as Chalk Rock, though, like every other exposure of the band along this coast, it is obviously in the zone of *Terebratulina gracilis*, and not in that of *Holaster planus*. Climbing on to the ledge, we found the same nodules over the greater part of its surface, and a fauna characteristic of the zone can be collected therefrom.

At the back of this big sloping ledge is a small vertical bluff, about 15 ft. high, splendidly weathered, and rich in fossils of the *T. gracilis*-zone. This little bluff is notable in being, with the exception of one other at Ballard Point, the only surface in this zone worth collecting from. Thickness of zone, 58 ft.

Zone of Holaster planus.

A little farther east we see the grey and flinty chalk of the *Holaster planus*-zone sloping to the beach. Under this flinty chalk there is about 10 ft. of rather flintless chalk, then a marl-band, followed by 8 ft. of rather flintless chalk based by another marl-band. This lower marl-band is the approximate junction of the zones of *Terebratulina gracilis* and *Holaster planus*, as the fauna of the latter zone comes in freely above the marl-seam. It is difficult to give an exact junction, as the surface is so pounded by the shingle.

Nearly the whole extent of this zone is too wave-battered to afford well-preserved fossils, though in less exposed spots they are sufficiently abundant to make it worth while to collect. The yellow nodular bands show up strongly, as at White Nothe, below the signal, and the grey marly nature of the chalk is very apparent.

This zone extends to a point immediately below a fine upstanding mass of chalk, locally known as the Fountain Rock, which is unnamed in the 6-in. map, though drawn there, and marked by the 300-ft. contour-line which comes out at the top of the cliff. At the foot of the Fountain Rock is a very strong nodular flint-line, which may be taken as the approximate lithological division between this zone and that of *Micraster cor-testudinarium*, for below it the comparatively abundant *Holaster planus* fauna suddenly ceases, and fossils become rare, while *Micraster* at once assumes the characters indicative of the *M. cor-testudinarium*-zone. Thickness of zone, 51 ft.

Zone of Micraster cor-testudinarium.

The chalk of this zone is cut in fine cliffs, but, apart from being hammered by the shingle, it is the most barren section of this bed which we have ever worked. The characteristic yellow nodular bands are present, but they are not prominent, and there is much smooth, hard chalk between them. The flints are black with thin white crusts. Fossils are so few and fragmentary that one has to rely on *Micraster* and *Echinocorys* for a determination of this zone. The latter is of the characteristic gibbous variety, and the former is of great help, as it fully conforms to the general rules, and by its means alone can one hope to fix the upper and lower limits of the zone. There is a singular absence of Bryozoa, usually so abundant at this horizon. As this zone is in comparatively horizontal chalk we hoped to obtain here an accurate idea of its normal thickness in Dorset, but the battered nature of the chalk, which strongly reminded us of Seaford Head in its negative zoological characters, prevented us from obtaining the same exact data as we got at Dover and Beachy Head, and the measurement which we give is, therefore, somewhat arbitrary. Thickness of this zone, 113 ft.

Zone of Micraster cor-anguinum.

The dividing line between the zones of *Micraster cor-testudinarium* and *M. cor-anguinum* is fixed at a strong ferruginous line of crushed and crowded flint, from 4 to 8 ins. thick, which reaches the shore about 100 yards east of Middle Bottom. Farther east along the shore, by some 25 ft., is a yellow nodular band, which might be more properly taken as the actual line of division; but the flint-line is so unique and striking in its appearance that we have given it the preference. This same flint-line is seen at Bat's Head, and was most useful when we got among the vertical and distorted beds.

It is generally a tedious task to separate this zone from the one below, especially when the lithological transition is so gradual and indefinite. The base of the *M. cor-anguinum*-zone is usually rather barren, but here we had the greatest difficulty in finding any fossils at all, and we are convinced that, in our anxiety to find a lithological feature which would serve us in the vertical chalk, we have under-estimated the thickness of this zone. Owing to the abnormal barrenness of the zone we doubt if we could ever obtain here a measurement which would be wholly satisfying. Thickness of zone, 171 ft.

The cliff at this point begins to show much evidence of disturbance. The beds are dipping sharply, and a fine series of slide-planes come into view. We trace this zone from the strong ferruginous flint-band to the first slide-plane, above which is the grass slope on which the sea-gulls nest. The chalk is firm and generally white, with regular lines of flint, with black cortices in the lower part, passing into grey in the upper part. The large iron-stained patches, which are so notable at Swyre Head and St. Oswald's Bay, are present here, and form a useful guide in recognising the zone, though it is, of course, a purely local feature.

We have before said that this is a poor section for fossils. However *M. cor-anguinum* and its var. *latior*, the ovate and dome-shaped varieties of *Echinocorys*, together with *Echinoconus conicus*, and the characteristic remains of *Bourgueticrinus* are present in sufficient number to enable one to determine the zone with certainty.

Zone of Marsupites testudinarius.

From the first to the second slide-plane is 81 ft., and from the second to the third is 30 ft. These measurements, curiously enough, coincide with the distribution of *Uintacrinus*- and *Marsupites*-plates respectively. Owing to the battered nature of the cliff *Uintacrinus* was difficult to find, and it says much for the value of this guide-fossil that it could be obtained in such apparently hopeless sections as this and Seaford Head. The characteristic *Echinocorys vulgaris* var. *pyramidatus* was fairly abundant from bottom to top of the zone, and in cliffs of this nature, where the shingle has pulverised all small fossils, its appearance, in section, will always be the best rough guide, and its presence alone will put one on the alert for *Uintacrinus*- and *Marsupites*-plates. The nipple-shaped head of *Bourgueticrinus* was also found. The flints are of a pale grey colour, with thick cortices, but not zoned. This condition is the same as that noticed at the top of the cliff 100 yards east of the signal at White Nothe, and it was this which induced Barrois to put the last 30 ft. of the cliff, immediately under the signal, into the *Marsupites*-zone. In point of fact, flints of the same character are found in the top of the *M. cor-anguinum*-zone.

Thickness of the zone ... ... { *Marsupites*-band, 30ft.
Uintacrinus-band, 81ft.

Zone of Actinocamax quadratus.

This zone extends from the third slide-plane to over one-third of a mile east of Middle Bottom, and it is the only coast-section in the south of England, save that between Black Rock and Arish Mell, where we have the greater part of this zone exposed. The first and last parts of this particular division of the section are very difficult to measure by reason of the slide-planes. We took every possible pains to make the measurements as accurate as possible, especially as the thickness of the zone was so great. It must be remembered that no coast-section has been recorded which gives a complete exposure of this zone, so that we have nothing to guide us as to its approximate thickness. We know of no boring which throws any light on the subject.

If the fault runs out at Middle Bottom it makes practically no difference to any calculations in measurement, for we know that there is a band containing *Actinocamax quadratus* on both sides of the little recess under Middle Bottom, and that this band is not more than 15 ft. thick, and practically undisturbed. Therefore, the fault, if it dies out here, has effected no obvious displacement, but has only riven and shattered the rock in all directions.

The measurements within the area of the fault are confessedly so difficult that we can only give them as we made them, in the hope that someone, skilled in surveying, will check our results.

It will be remembered that, before we reach the part of the cliff assigned to this zone, the beds are dipping sharply, so that they are well within the trough of the syncline. We carried the *Marsupites*-zone up to the third slide-plane east of White Nothe. Taking the beds from this point to the centre of Middle Bottom, where the trough of the syncline brings them almost horizontal for a space of about 100 yards, we obtain the following measurements:

3rd to 4th slide-plane	50 ft.
4th to 5th „ „	54 ft.
5th to 6th „ „	48 ft.
6th to 7th „ „	26 ft.*
7th to 8th „ „	26 ft.
	204 ft.

We have, then, 204 ft., measured from the junction with the *Marsupites*-zone to the lowest flint-line under Middle Bottom, and the cliff above that is about 50 ft. A fall from near the top of the cliff, on the west side of Middle Bottom, yielded an *Actinocamax quadratus*-fauna. Therefore we have about 254 ft. of this zone exposed up to Middle Bottom. Probably a considerable thickness has been cut away at the top of the cliff, and we incline to the belief that this zone cannot be less than 350 ft. thick, and we should not be surprised if it were more.

We now take up our measurements on the east side of Middle Bottom, beginning at the same flint band where we left off. They are as follows:

8th to 9th slide-plane	100 ft.
9th slide-plane to a point opposite the Calf Rock .	173 ft.
	273 ft.

For several hundred yards east of Middle Bottom the cliffs are not much disturbed, but as soon as we reach the point where the beds curve up sharply slide-planes are common, and we enter a belt of shattered chalk. The *Actinocamax quadratus*-chalk on the east side of Middle Bottom must be a repetition of that on the west side, and we here obtained a measurement of 273 ft. If we add the 50 ft. above the lowest flint line at Middle Bottom we obtain a thickness of 323 ft. as exposed. The measurements on either side of Middle Bottom do not tally, but we prefer to give them just as we made them out, as finality in measurement in rock such as this is not the portion of the amateur worker.

This zone extends along the shore for over half-a-mile, and were it not so battered by the shingle would yield many fossils. Even in the badly slipped and fractured beds in the eastern half of the section we found *Echinocorys vulgaris* var. *gibbus* in

* Last strong band of *Cardiaster pillula* west of Middle Bottom.

abundance, but always in section. The same applies to *Cardiaster pillula* and other characteristic fossils.

Eastward of the sixth slide-plane, and up to Middle Bottom, the chalk alters much in appearance, and exhibits a yellowish tinge. In fact, from our experience of the Wool Chalk, we thought that we were about to work the *Belemnitella mucronata*-zone, and it was only by collecting that we proved that this was unquestionably not the case. The flints were of the same appearance as in the *Marsupites*-zone. The last strong band of *Cardiaster pillula* was found at the seventh slide-plane, east of Middle Bottom.

As we have before mentioned, we had the good fortune to strike a narrow band yielding *Actinocamax quadratus*, the first example occurring at the base of the low cliff under Middle Bottom. Luckily, the beds keep nearly horizontal for a space, and then rise gradually as we pass to the east, so that we were enabled to trace this band for nearly a sixth of a mile. We secured fifteen examples of this useful fossil, all of which we had no difficulty in assigning to this species ; but that there might be no doubt on the point, we referred them to Mr. Crick, who at once confirmed our determination. This is a new record for this coast, and one hitherto quite unexpected.

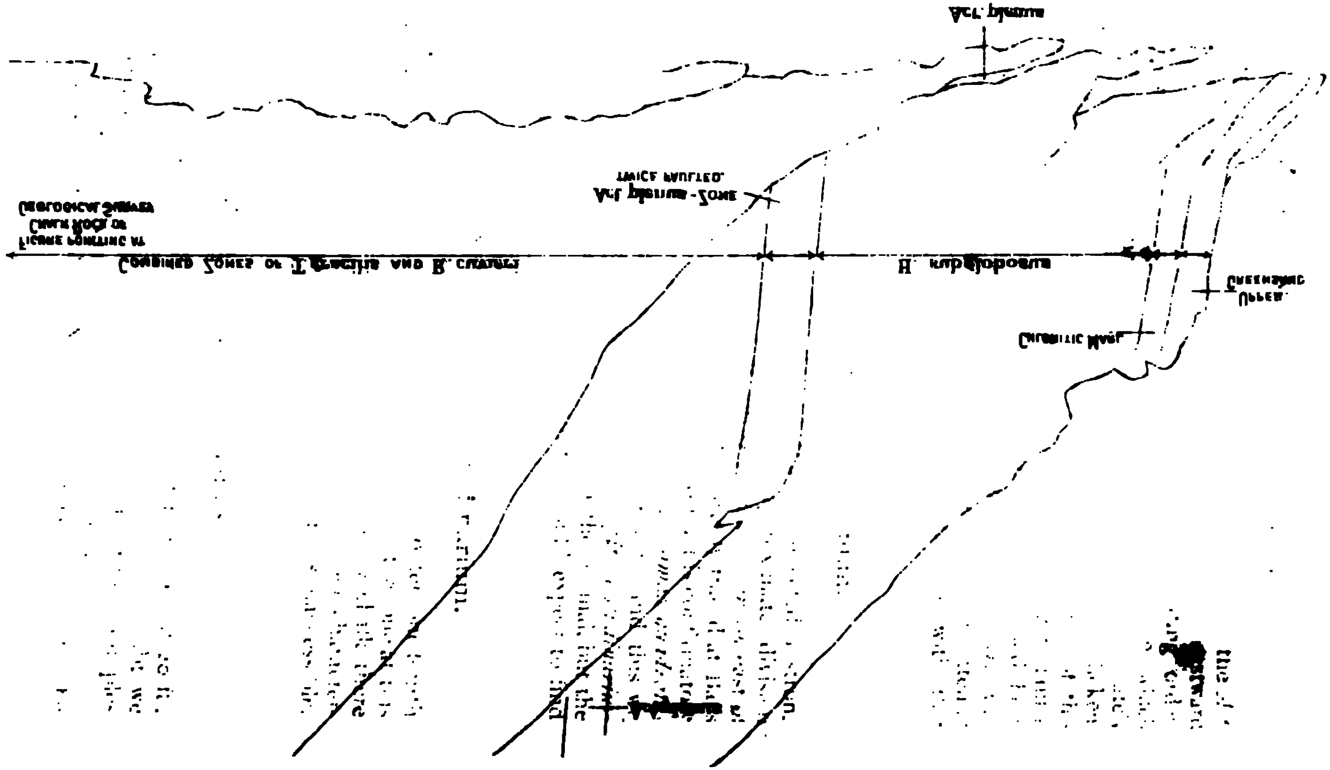
Half-way between Middle Bottom and Bat's Corner the beds begin to rise sharply, and a few yards west of the ninth slide-plane, which is a very prominent one, is a strong band of *Cardiaster pillula*. From this point onwards the chalk is greatly shattered and slickensided, and little slide-planes are abundant. We found a tip of a Belemnite 173 ft. east of the ninth slide-plane, almost opposite the Calf Rock, and a few yards farther east we had the good fortune to discover a plate of *Marsupites*. It is evident, therefore, that this could only be an example of *Actinocamax granulatus* (*A. merceyi*),* as we found three of them *in sitû* at a corresponding point between Black Rock and Arish Mell.

We have, then, no *Belemnitella mucronata*-zone exposed on the west side of Lulworth, and nowhere, save at Arish Mell, do we get any zone higher than that of *Act. quadratus*. When we were on our way to the top of Bat's Head, however, we found an example of *B. mucronata* in the mouth of a rabbit's hole. This spot was in a straight line with the signal at White Nothe and the gate on the extreme point of Swyre Head. A little south of the coastguard path, and in a line with Bat's Head, is a small one-roomed building, and south of this is a place where the turf has been removed for a space of 20 ft. by 10 ft. In this chalk we found over a dozen examples of this fossil. We were probably in the horizontal *B. mucronata*-chalk.

* Since the Kent and Sussex paper was written we have gone into the question of the nomenclature of this Belemnite, and we find that *Actinocamax merceyi*, Mayer-Eymer, is none other than *Act. granulatus*, Blainville, and throughout the present paper we shall refer to it under that name, putting *merceyi* in brackets. so that readers of the first paper may know to what species we allude.

DURDLE COVE

Pl II



Durdle Cove, looking towards the East

Zone of Marsupites testudinarius.

We have noted that we reach the highest point in the *Act. quadratus*-zone at Middle Bottom. As we pass farther eastward of this point we must traverse the beds in descending order. Opposite the Calf Rock we found a *Marsupites*-plate, which gives us an approximate upper limit for this zone. Unfortunately the cliff is so pounded by the shingle, and so crushed and slickensided, that it is impossible to give the exact limitations of this zone. On our first visit we found no trace of *Marsupites*-fauna, but on another occasion, after much labour, we obtained both *Marsupites* and *Uintacrinus*, as well as *Echinocorys vulgaris* var. *pyramidatus*. We were, therefore, forced, as far as an attempt at measurement is concerned, to merge this zone with that of *Micraster cor-anguinum*.

Zone of Micraster cor-anguinum.

It will be remembered (p. 10) that we selected a strong ferruginous line of crushed flint as the approximate division between this zone and that of *Micraster cor-testudinarium* east of the Fountain Rock. This band of flint is readily traced at Bat's Head, and the yellow colour of the chalk beyond it is confirmatory evidence. From the base of the zone of *Actinocamax quadratus* to the ferruginous flint-band we measured 205 ft., and this we offer as the combined measurement of the *Marsupites testudinarius*- and *Micraster cor-anguinum*-zones. It is below the normal, but the crush is very great at this corner, and we should expect to find the thickness reduced.

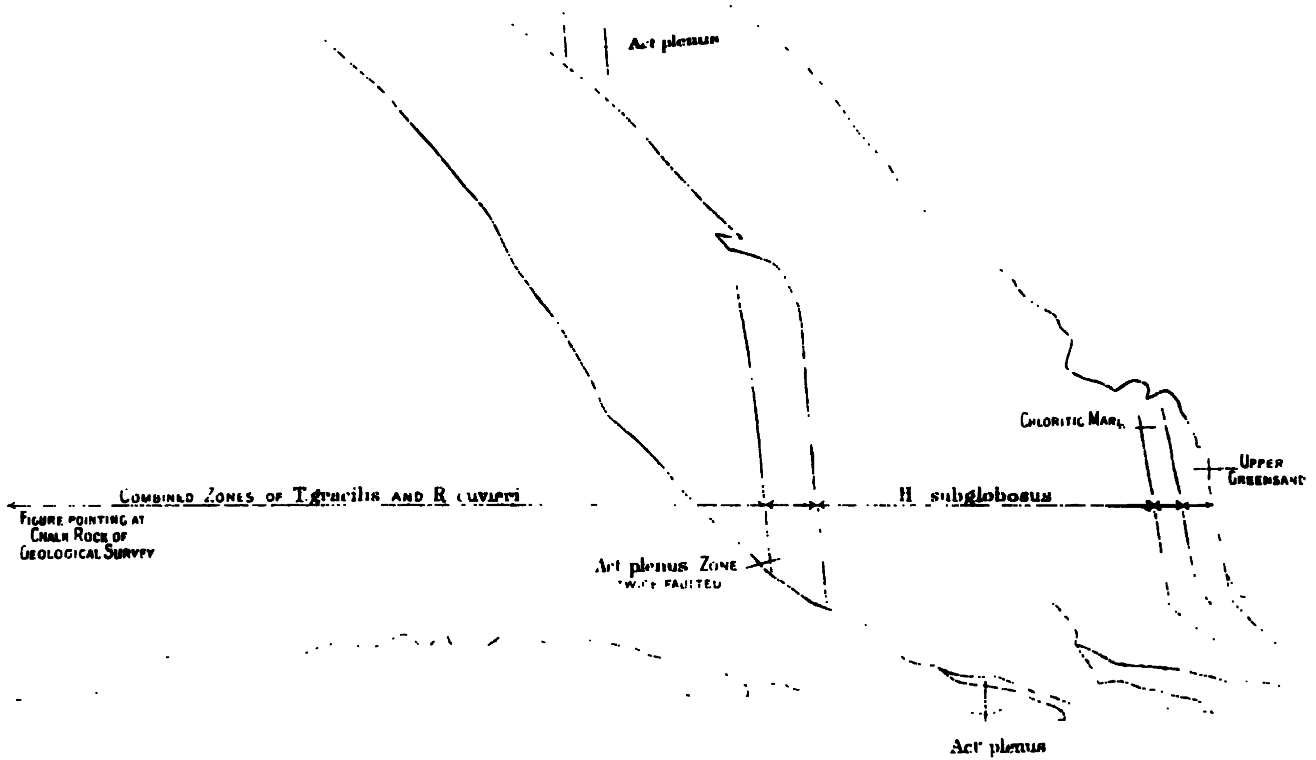
Zone of Micraster cor-testudinarium.

From the strong ferruginous flint-line to the outer one-fourth of Bat's Head is about 110 ft. We fix the base of the zone at this point, because the yellow *Micraster cor-testudinarium* chalk there passes into the grey colour of the *Holaster planus*-zone characteristic of this coast. Nearly the whole of this zone is inaccessible, as the headland is tide-washed.

Zone of Holaster planus.

The seaward end of Bat's Head, for a distance of about 20 ft., is clearly in this zone. To put the question beyond doubt we gained a footing on it from a boat, and knocked out two examples of *Micraster*, which were characteristic of the zone.

This section from White Nothe to Bat's Head can only be



DURDLE COVE.

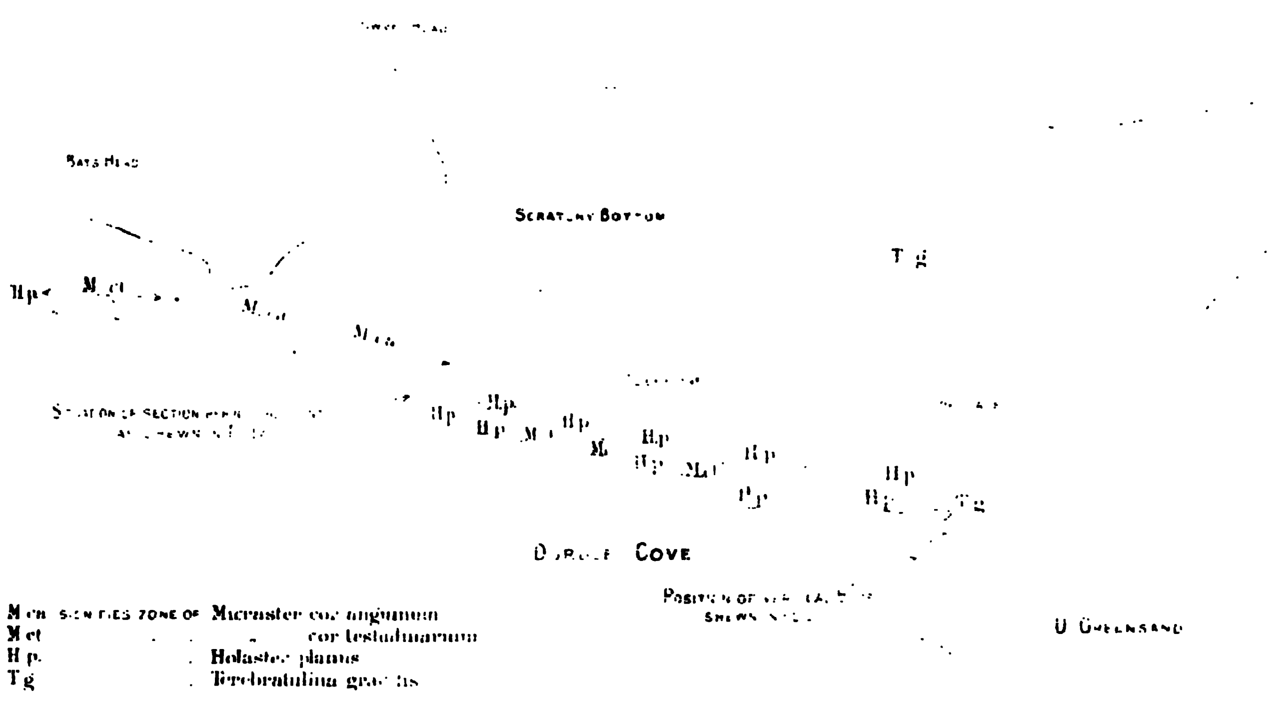
Pl. II

The slide-plane traverses two sets of zones. In its eastern part it has the zone of *T. gracilis* above and below it; a little farther west the zone of *T. gracilis* above and that of *H. planus* below; while in the western and greater part of its extent, it has the *H. planus*-zone above, and the *M. cor-testudinarium*-zone below, except where the projections at the foot of the cliff jut out farthest, when it is again in the *H. planus*-zone. Lastly, the western angle of the little cliff, being cut in the zone of *H. planus*, the slide-plane intersects this zone alone.

Along the line of weakness caused by the slide-planes the sea has hollowed out a series of little caves. The roof in all cases has been pushed northward over the floor of the cave. In the eastern part of the slide-plane the separation has been marked by a sharp line, but in the western part the floor of the cave has been ground up into a paste, and cemented together again. As we have indicated, the tip of the little promontory, which forms the western horn of Durdle Cove, is cut in the zone of *Holaster planus*. This is suggested by the grey colour of the chalk, but was accurately determined by its fossils. In the eastern part of this section a second small slide-plane is seen, at a higher level than the main one. The value of *Micraster* as a zonal-guide was never more clearly in evidence than in this case. The base of the cliff juts out into the sand in a series of little projections, and we were able, in half-an-hour's collecting, to assign each little area to its own zone. The determination of the zone by the aid of *Micraster* was so definite, and the result so impossible to obtain in any other way, that we regard it as one of the most searching proofs of its reliability in differential determination with which we are acquainted. Durdle Cove gives us, then:

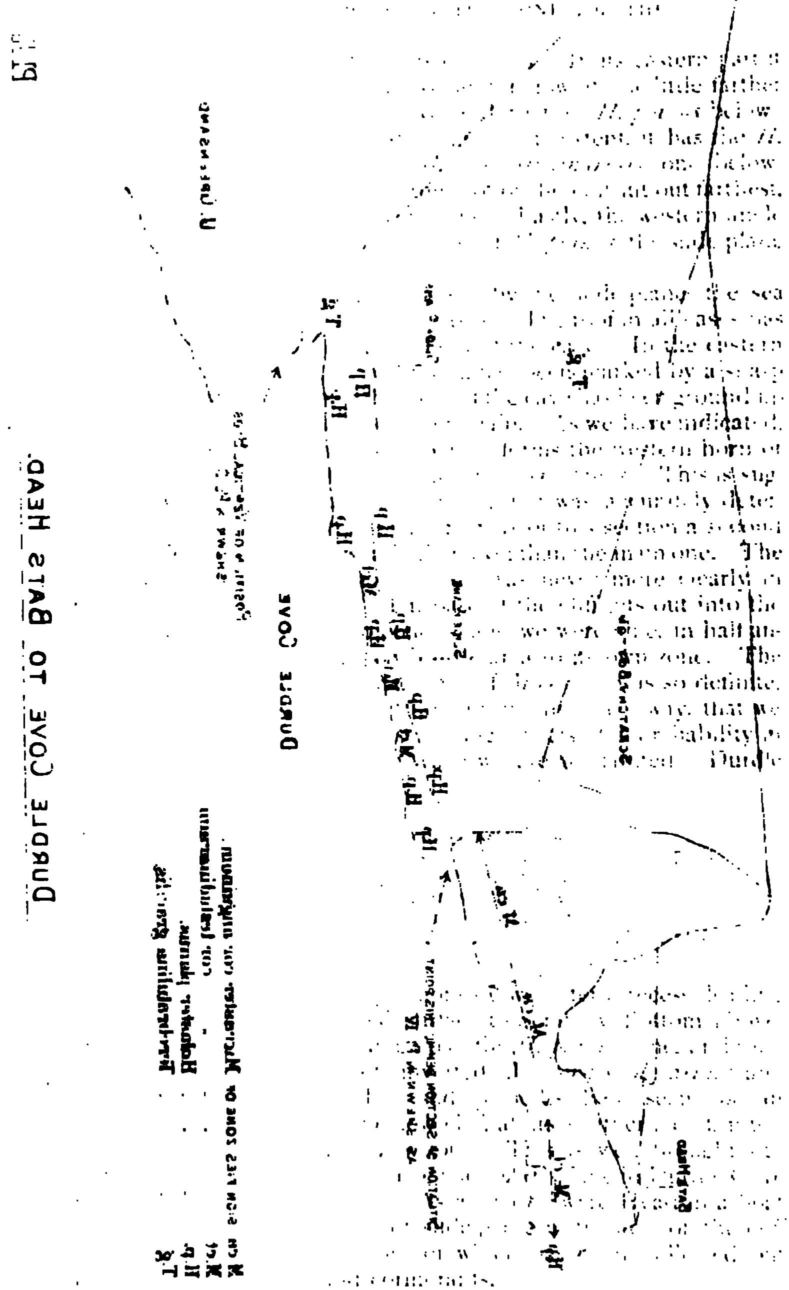
Zone of *Rhynchonella cuvieri* and *Terebratulina gracilis* combined	70 ft.
Zone of *Holaster planus*, exposed only at the tip of the little promontory, above the slide-plane, and in the little projections at the foot of the cliff	about 15 ft.

Passing round the little promontory we enter a recess, leading by a narrow water-channelled surface to Scratchy Bottom above. We have at the corner the same tip of the *H. planus*-zone, and then follows a good section of inverted *M. cor-testudinarium* and *M. cor-anguinum*-zones. The slide-plane is here seen as an oblique line half-way up the low cliff, at its southern end, intersecting the *M. cor-testudinarium*-zone. This is well brought out in the photograph (Pl. IV). The main slide-plane in Durdle Cove is a continuation of this one. As we pass Swyre Head in a boat we can see two distinct lines of slide-plane in the top of the cliff (zone of *M. cor-anguinum*), one of which has been hollowed out by the nesting of gulls and cormorants.



M ca signifies zone of Micraster cor anguinum
M ct " " " cor testudinarium
H p. " " Holaster planus
T g " " Terebratulina gracilis

DURDLE COVE TO BATS HEAD.


DURDLE COVE TO BATS HEAD.
DURDLE COVE
BATS HEAD

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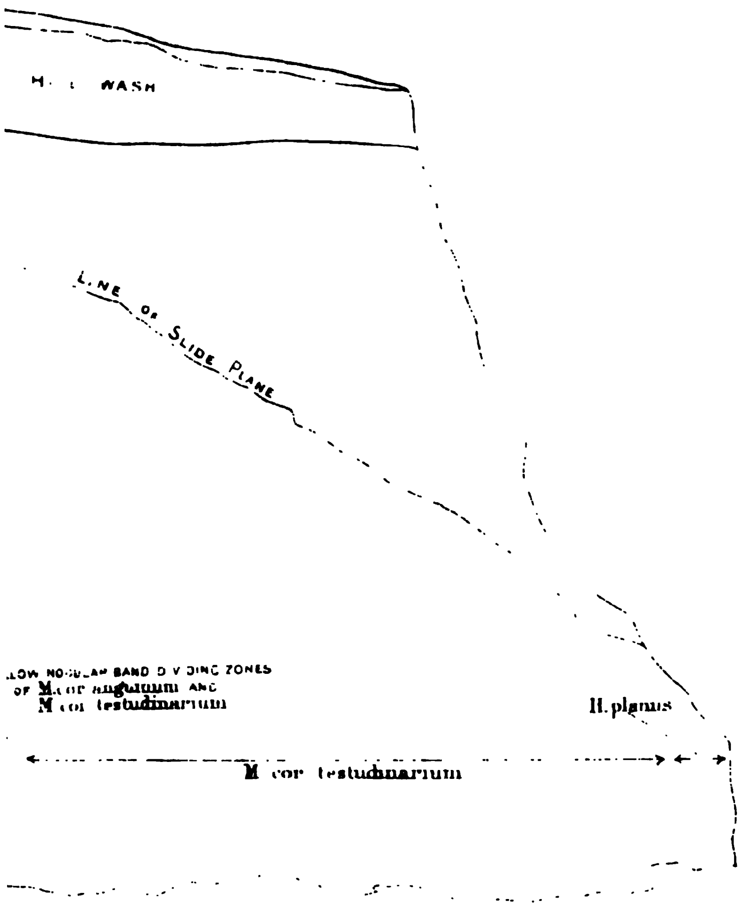
o'-War Rock, but the beds between this and the zone of *Rhynchonella cuvieri*, which forms the face of the little headland dividing this Cove from St. Oswald's Bay, have been washed out. However, we can trace part of them with the greatest ease at low water, for we can walk over the up-turned ledges of the *Actinocamax plenus*-marls, the *Holaster subglobosus*-zone, the Chloritic Marl, and the Upper Greensand.

On the western side of the Cove we can trace the Upper Greensand and *Holaster subglobosus*-zone, but the beds are mostly covered with talus. We also get a section of much altered and compressed *Rhynchonella cuvieri*- and *Terebratulina gracilis*-zones. We know that this is one of the points of maximum crushing, and are quite prepared to find some of the beds reduced. The exposure of the zones of the west side of the Cove is a poor one, and we did not find it possible to measure them.

On the east side of the Cove, however, we obtained a thickness for the *Rhynchonella cuvieri*-zone of 72 ft., and for the *Terebratulina gracilis*-zone of 29 ft., making a combined measurement of 101 ft., as against the 70 ft. given for Durdle Cove. It is possible that we may have given too much to the former zone, from the simple fact that the beds are so altered that it is difficult to find sufficient fossils to provide limiting lines. When we examine the other side of the Man-o'-War Head we shall see that the *Holaster planus*-zone is squeezed up to a mere band, so that it is quite possible that the zone immediately below it has suffered in proportionate degree. There is a band of black nodular flints, with thick grey crusts, near the base of the *Rhynchonella cuvieri*-zone, as at White Nothe.

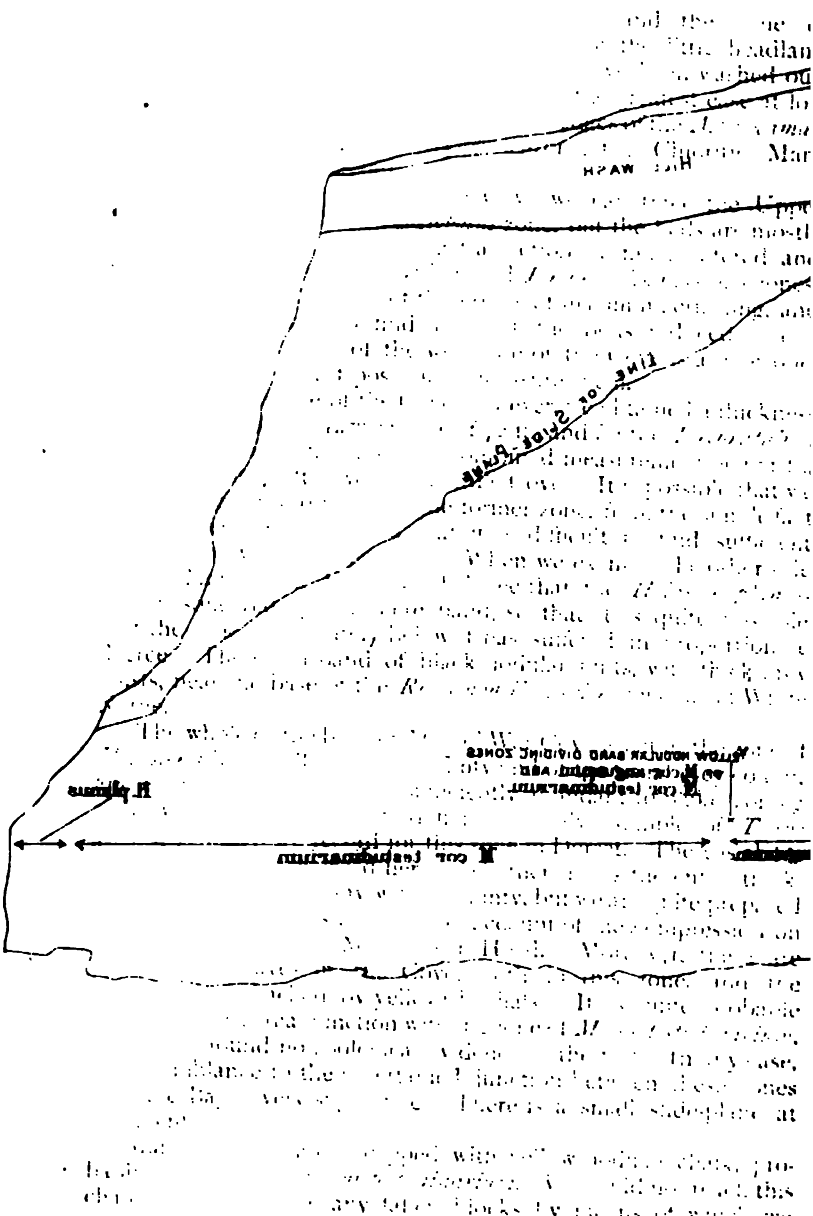
The whole of the back of Man-o'-War Cove is cut in the zone of *Holaster planus*. The chalk is flinty and of the usual grey colour, and characteristic fossils are sufficiently abundant to make zoning a fairly easy task. We found here the only example of *Turbo gemmatus* which we record for this zone in Dorset. There is about 25 ft. of this zone exposed here. Whether this is the entire thickness we are unable to say with certainty, but we are quite prepared to believe that such is the case, on account of the compression on the other side of the Man-o'-War Head. Moreover, there are two shallow caves in the Cove, both in this zone, and the western one is backed by yellowish chalk. It is quite probable that this is the actual junction with the zone of *M. cor-testudinarium*, though we found no zoological evidence of the fact. In any case, the resemblance to the ascertained junction between these zones at Mupe Bay is very suggestive. There is a small slide-plane at this point.

Man-o'-War Head is capped with yellow nodular chalk, probably in the zone of *M. cor-testudinarium*. We could not reach this chalk, nor were there any fallen blocks by means of which we could make a determination.



DURDLE COVE.

Pl. IV



Pl. IV

DURDLE COVE

EASTERN CLIFF-FACE, SCRATCHY BOTTOM.

St. Oswald's Bay.

Standing on the western slope of Dungy Head a magnificent view of alternating bay and headland stretches away westward to White Nothe. It is the fairest picture within the Chalk area, and it evidently so appealed to the artistic sense of Sir John Millais, for he selected it for the scene of his picture, "The Romans leaving Britain."* So faithfully has he drawn it that it would well serve as an illustration for a memoir on this coast.

This bay can be worked from either end, as the lower beds are well shown on both sides of it. We have already given the measurements of the zones of *R. cuvieri* and *T. gracilis* on the western side of Man-o'-War Head, so we shall continue our work from that point.

Zones of Rhynchonella cuvieri and Terebratulina gracilis.

We separate these two zones, and obtain a measurement of 45 ft. for the former, and 40 ft. for the latter—a difference of 16 ft. on the two sides of the headland. The mere variation in measurement of the two zones in question matters but little, as everywhere in this crushed and vertical chalk it is a most difficult task to separate them. The divergence in a combined measurement of the two zones, however, is quite another matter, for there can be no possible doubt in fixing the top of the *Terebratulina gracilis*-zone, or the base of the *Rhynchonella cuvieri*-zone. We do not seek to explain away this discrepancy, but we should have expected that, if there were any variation, the increased measurement would have been on the western side of the headland, for the reason that the *Holaster planus*-zone is squeezed up to a mere band on the eastern side. It may prove of interest if we summarise at this point the combined measurements of these two zones at three neighbouring sections:

Durdle Cove	70 ft.
West side of Man-o'-War Head	101 ft.
East side of Man-o'-War Head	85 ft.

The difference in the combined measurements of these two zones, at points so near together, is very remarkable. Amateur measurements may have something to do with it, but they cannot possibly explain it all. Moreover, all along this coast, wherever the crushing is most obvious, we get wonderful discrepancies in measurements, and one of the most notable features is the way in which the different zones appear to be unequally compressed at any given point.

* "The Life and Letters of Sir John Everett Millais," by J. G. Millais, vol. i, p. 387, Methuen & Co., 1900.

The Chalk Rock of the Geological Survey is well shown in the zone of *Terebratulina gracilis*, being in this instance 14 ft. below the base of the zone of *Holaster planus* (Pl. V).

Zone of Holaster planus.

The remarkable effect of compression on this zone is demonstrated in Pl. V. At one point the zone cannot measure more than 4 or 5 ft. across, and even where it expands most it cannot be more than 15 to 18 ft. However, there can be no doubt about it being the *H. planus*-zone, for the appearance of the chalk tallies with all other sections on this coast, and the fauna, though scanty, is quite characteristic.

Zone of Micraster cor-testudinarium.

We next pass a very poor section of this zone, and obtain a measurement for it of 68 ft. But for the presence of *Micraster* we could not possibly have determined this bed.

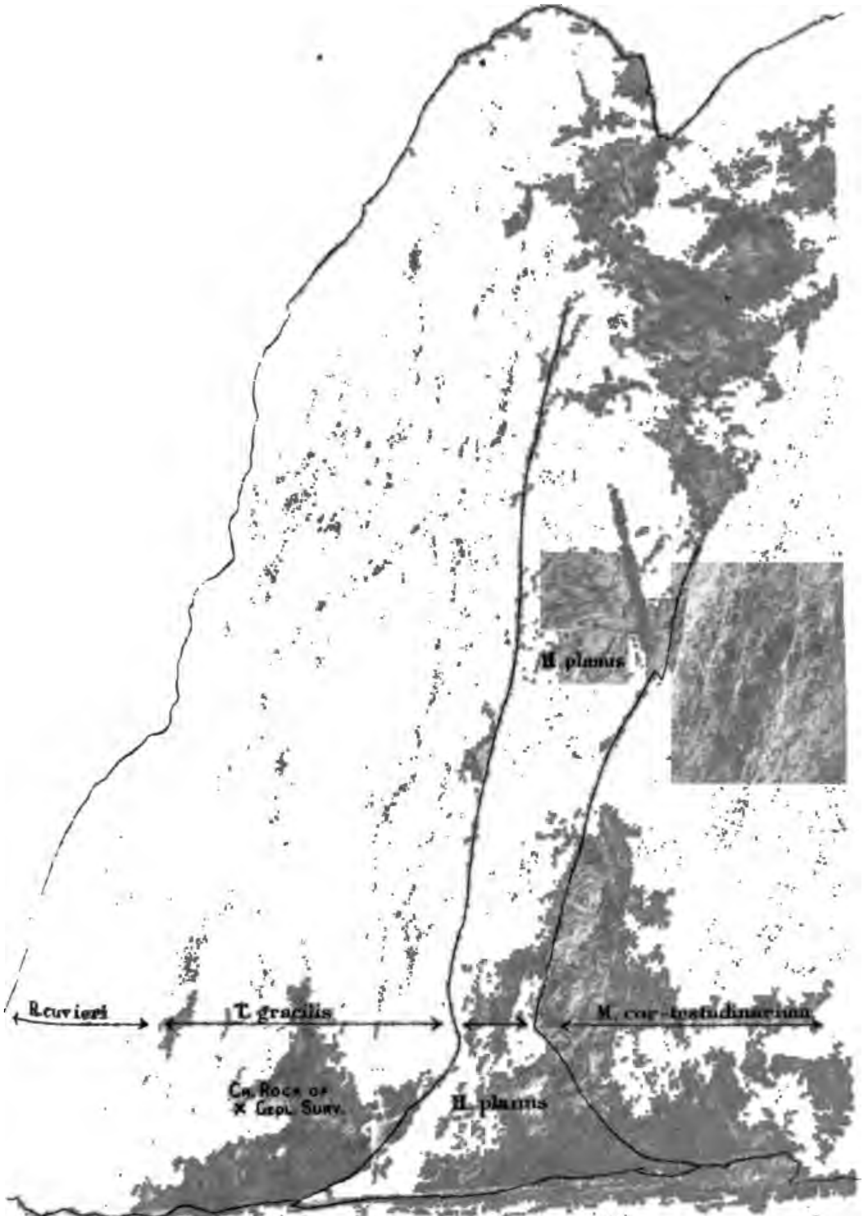
Zone of Micraster cor-anguinum.

This zone forms the head of the bay, and is, therefore, the highest bed seen in this particular section. Its junction with the zone below it is fixed at about 15 ft. west of a cave, which is itself a little west of Red Hole. The chalk is massive, and the flint-bands numerous. *Micraster cor-anguinum* and its var. *latior*, *Echinoconus conicus*, and the characteristic ovate and dome-shaped *Echinocorys*, were found here. Fossils are by no means abundant, and are especially scanty towards the base. *Echinoconus* is most abundant in the middle of the zone, near a very strong and conspicuous flint-band.

There are remarkable red areas in this chalk, due to fine veinings of oxide of iron, often arranged in wavy outlines, like those of an agate. We have noted it at White Nothe and Swyre Head, but it is most developed here. It is quite impossible to measure this zone, and, in any case, it is incompletely exposed. We trace this bed to a point where the cliff juts out to the south, and where the chalk is of an obviously yellower colour. This gives us the junction with the zone of *M. cor-testudinarium.*

Zones of Rhynchonella cuvieri and Terebratulina gracilis.

Having reached the highest zone in the bay, we must start afresh from the eastern end of the Chalk. We see here an exact copy of the vertical beds, from the Upper Greensand to the zone



WEST END ST. OSWALD'S BAY.

Pl. V.

of *Holaster planus*, which we have described in Durdle Cove. Plate II will serve equally well for this section, even to the faulting in the *Actinocamax plenus*-marls. The two zones under discussion are so wave-worn and altered that it is impossible to separate or measure them.

Zone of Holaster planus.

Rounding this advanced part of the cliff we pass westwards, and come to a little recess where the chalk is greyish. Collecting from it we obtain an abundant fauna of this zone, *Micraster* being well represented, but the name-fossil absent. A slight slide-plane is seen, which is a feeble repetition of that at Durdle Cove, and the zones of *H. planus* and *M. cor-testudinarium* are in the same relative position as at Durdle.

Zone of Micraster cor-testudinarium.

Still passing westward we reach the advanced mass of yellowish chalk, at the western angle of which we broke off our survey. The name-fossil and *Echinocorys vulgaris* var. *gibbus* were fairly abundant, and place the determination of this zone beyond question. The exposure is obviously incomplete, so we did not attempt to measure it.

It will be seen, therefore, that St. Oswald's Bay is only a larger edition of Man-o'-War Cove, though it carries us up two zones higher.

Lulworth Cove

Here we have the perfect example of an almost circular bay, caused by a breach in the Portland Stone barrier. It is, however, a poor section to work for Chalk fossils, as the head of the bay is chiefly a mass of slipped chalk. East of the stream the succession of beds between the Upper Greensand and the *Actinocamax plenus*-marls can be traced, near the old lime-kiln, among the fallen masses of chalk. The base of the cliff, at the time when we examined it, was entirely cut in the zone of *Rhynchonella cuvieri*. Farther east, past Black Rocks, are two fine vertical faces of the *Holaster planus*-zone, well up in the cliff, and blocks of this chalk have fallen on the beach, and yield good lists of characteristic fossils. Above this we can see the *Micraster cor-testudinarium*-zone, but there were no fallen blocks on the shore to verify our statement, and this part of the cliff is inaccessible. We were able to find one face of the *Terebratulina gracilis*-zone, in the eastern part of the chalk exposure, by climbing up a talus. The *R. cuvieri*-zone yielded a fair list of typical fossils ; but there is no need to go into details, as the section is like all the others in this zone. No measurements could be taken. A perpetual spring of fresh water gushes out at Black Rocks. This is the only one between Lulworth and White Nothe.

MUPE BAY.

This is the western end of a large bay, the eastern end being called Worbarrow Bay, and the central recess Arish Mell. The simplest plan is to follow up our scheme of working from the west. We reach Mupe Bay by boat, or by climbing the low cliff at the east side of Lulworth Cove, and then striking up in a N.E. direction till we reach the path under Bindon Hill, which has a hedge on the south side of it. This leads us straight to Mupe Bay. We can climb down the sloping cliff at once, or better still, get over the stile and make for the Look-out over Bacon Hole. The distance is only a mile.

The Look-out is situated just above the Mupe Ledges (Portland Stone), which stretch out towards the eastern horn of the bay, giving one some idea of the old barrier of Portland Stone. The line, however, is not a direct one, as one can see by consulting the map. The fishermen put down their lobster-pots on the sunken reef, and in answer to our question about the direction of the reef, told us that if they dropped their pots in the centre of the bay, in a line with Worbarrow Tout, they got on soft bottom, but that if they took them farther north, they touched the reefs at once. This will illustrate the curious twist in the beds, to which we shall allude later on.

From the Look-out we get not only one of the finest views on the coast, but we obtain a graphic idea of the way in which the beds have been cut back. Mupe Bay takes us as high as the zone of *M. cor-anguinum*, Arish Mell up to the *B. mucronata*-zone, and Worbarrow Bay (on the top of the cliff) to the *Marsupites*-zone. It is probable that we have higher chalk at the top of the cliff at Mupe Bay, but it is inaccessible, and we only give what we know from rigid collecting.

We descend to the shore at Mupe Bay and make for the buttress of Upper Greensand facing south. Here we see the same section as in Durdle Cove and St. Oswald's Bay, but it faces east instead of west. We pass over the usual succession of beds, and reach the zone of *R. cuvieri.*

Zone of Rhynchonella cuvieri.

This is a poor section of the zone, and much wave-worn. However, by patient collecting we can get a reliable list of fossils, and can separate it from the zone above. It contains a marl-band but we noticed no line of flint near the base. There is no definite

Grit Bed or Melbourn Rock here, or in any other section of the zone. The zone measures 49 ft.

Zone of Terebratulina gracilis.

This bed is less nodular, but, if anything, harder than the preceding. It contains a few marl-bands, but no flints, and runs out in reefs to within 100 ft. of Black Rock, forming the outer edge of the base of the cliff. On the top of the outer ledge is seen the Chalk Rock of the Geological Survey. Here it is 15 ft. below the junction of the flintless *T. gracilis*-zone with the flinty *H. planus*-zone. The fauna is not abundant but is sufficient for the determination of the zone. We have here a combined measurement, for this zone and that of *R. cuvieri*, of 78 ft., which closely corresponds with the combined measurement obtained at Durdle Cove. The *Terebratulina gracilis*-zone measures 29 ft.

Zone of Holaster planus.

With the exception of the cave, on the west of Black Rock, the remainder of the accessible part of this section is all cut in this zone. It is the only section of this bed worth working, but to those who are accustomed to a prolific *H. planus*-fauna it will be disappointing. It affords, however, one new and interesting zoological feature, for we find a band crowded with the beautifu little rotiform Bryozoon which is labelled *Defrancia* in the Jermyn Street Museum, and derived from Arreton, Isle of Wight, from the same zone.* This band is here about 2 ft. thick, and is shown on the seaward face on the lowest ledge of the *H. planus*-zone, about 3 ft. above the last flint-band. We trace it right up the reef into the cliff.

This section yields a fair list of all the characteristic fossils, and is of the grey colour customary in this district. Yellow nodular bands are inconspicuous, and are only well seen at White Nothe, on the undercliff and on the shore. The zone measures 49½ ft.

Zone of Micraster cor-testudinarium.

But little of this zone is exposed. Black Rock † itself is mainly in this chalk, but its extreme point is in the zone of *H. planus*. This we proved by landing from a boat, and collecting a number of characteristic *Micraster*. The cave, as Barrois states, is in this bed, and yielded *M. præcursor* and *M. cor-testudinarium* of the group-forms peculiar to the zone. Above the entrance to the cave is a flat surface of the yellow colour which this zone locally

* We understand that Prof. Gregory has described this Bryozoon in the MS. for the second volume of his "Cretaceous Bryozoa."

† The name, Black Rock, refers to the little tide-washed headland which can only be rounded in a boat. In the map appended to this paper the name is attached in error to an unnamed rock to the east of Black Rock.

assumes, and one can readily follow the same flat surface up the cliff; it gives an admirable base for measuring the *H. planus*-zone, for this flat surface is the actual dividing line of the two zones. It will be remembered that we noted the same condition in the cave in Man-o'-War Cove. This zone measures about 60 ft.

Above the beds of *M. cor-testudinarium* we can see the whiter chalk of the *M. cor-anguinum*-zone, with its more regular and less crowded flint-lines. This chalk could possibly be reached, but the talus was very unstable, and we did not consider that it was worth the risk to prove a point that was perfectly obvious.

Black Rock to Arish Mell.

We must follow up the beds in their ascending order, so we shall begin again on the east side of Black Rock. There are two ways of reaching this point. We can land from a boat, but this can only be done on a smooth sea, as the shore is a mass of rocks. Black Rock can generally be reached on foot at any really low tide from Arish Mell, though we should strongly advise the collector to follow a falling tide, as there is no way up from the shore, and the precipitous cliffs are tide-washed. The sea runs up very quickly to the eastern corner of Cockpit Head, and as we had several narrow escapes, we give the warning seriously.

Zone of Micraster cor-testudinarium.

We know that this zone passes through Black Rock, for we saw it on the west side of that little headland. When we were there, the tide was not sufficiently low for us to measure the zone in its entirety, but we judge it to be about 50 or 60 ft. thick. The junction of the yellow nodular chalk with the zone of *M. cor-anguinum* is obvious.

Zone of Micraster cor-anguinum.

We take our junction of this zone with the one below it from the point where the yellow nodular chalk of the *M. cor-testudinarium*-zone passes into the white chalk of the *M. cor-anguinum*-zone, with its more regular bands of flints. When we examined this section we had not fixed on the strong ferruginous flint-line at White Nothe (p. 10), and could not, therefore, use it in this instance. We made several attempts to visit this section again, but on each occasion the sea prevented us from doing so. However, on our first visit, the tide was sufficiently low for us to obtain an accurate zoological junction between these zones, and this we got with comparative ease. We trace this zone in an easterly direction until we come to the first *Uintacrinus*-plate. This gives us a measurement of 193 ft.

for the zone. It is a very difficult bed to measure, but we went over it several times, and on each occasion our figures came out at about 200 ft.

It will be noticed that east of Black Rock is a small bay with a sand and shingle beach. It is limited by Black Rock on the west and by a small projection on the east. It is the only little bay between Black Rock and Arish Mell, and is important because there we obtain our junction with the *Marsupites*-zone.

Zone of Marsupites testudinarius.

We cannot give any physical feature to guide other observers in finding the base of the *Uintacrinus*-band, for the cliff affords no clue of this nature, nor is there anything in the general appearance of the two zones to indicate that we are passing from one to the other. We may mention, however, that the *Uintacrinus*-plates occur towards the eastern end of the little bay already mentioned, and that we trace them there for a thickness of 17 ft. only. This brings us nearly to the eastern angle of the little bay, and we here get a junction of the *Uintacrinus*- and *Marsupites*-bands. Then the little projection already mentioned brings in *Uintacrinus* again for a space, and still farther east is a small cave which yields both *Uintacrinus*- and *Marsupites*-plates in their proper relative position. We could only get a thickness of 12½ ft. for chalk yielding *Marsupites*-plates. Still passing east, we work over a short flat surface of cliff where *Marsupites*- and *Actinocamax quadratus*-faunas mingle, for in the western part we find *Echinocorys vulgaris* var. *pyramidatus*, and in the eastern part the var. *gibbus*; but no *Marsupites*-plates or *Cardiaster pillula* were seen. This brings us to a point opposite Barber's Rock, where the *Act. quadratus*-fauna comes in strongly. It will be noticed that this gives us a thickness of but 29½ ft. for the whole *Marsupites*-zone. Even taking compression into consideration, it is not likely that this bed would be reduced here to that extent. It must be remembered that there is no lithological distinction between the *Marsupites*-zone and the zones immediately above and below it, and that nothing but rigid collecting gives one the faintest chance of obtaining the junctions between the various beds. The chalk is much compressed, slickensided, and pounded by the shingle, and it is possible that at another visit both the upper and lower limits of this zone might be considerably increased by more fortunate collecting. However, we prefer to give the facts as we found them, making no attempt at an ideal measurement, for we got definite zoological junctions, which were worth obtaining in chalk of this nature.

It will be observed that after we found the highest *Marsupites*-plate we traversed an area which was devoid of both

Marsupites and *Cardiaster pillula*, but in which *Echinocorys vulgaris* var. *pyramidatus* was found. This area would naturally fall within the *Marsupites*-zone. In the paper on Kent and Sussex (*op. cit.*, pp. 333-338), we note that there is generally an area between the zones of *Marsupites testudinarius* and *Act. quadratus* where *Marsupites* dies out and *Cardiaster pillula* has not yet appeared, but in which we trace an orderly transition in *Echinocorys* from the var. *pyramidatus* to the var. *gibbus*. When the true var. *gibbus* comes in we at once expect to find *C. pillula*. The coincidence of these two fossils invariably marks the true base of the *Act. quadratus*-zone. What is true of Sussex is equally valid here. In this section about 15 ft. could be apportioned to the *Marsupites*-zone, in addition to the area actually containing *Marsupites*-plates. In the White Nothe section the same zoological conditions obtained, but we were unable to trace them so definitely, on account of the damaged nature of the surface. In the latter section we were not fortunate enough to find *Act. granulatus* (*A. merceyi*) at the base of the *Act. quadratus*-zone.

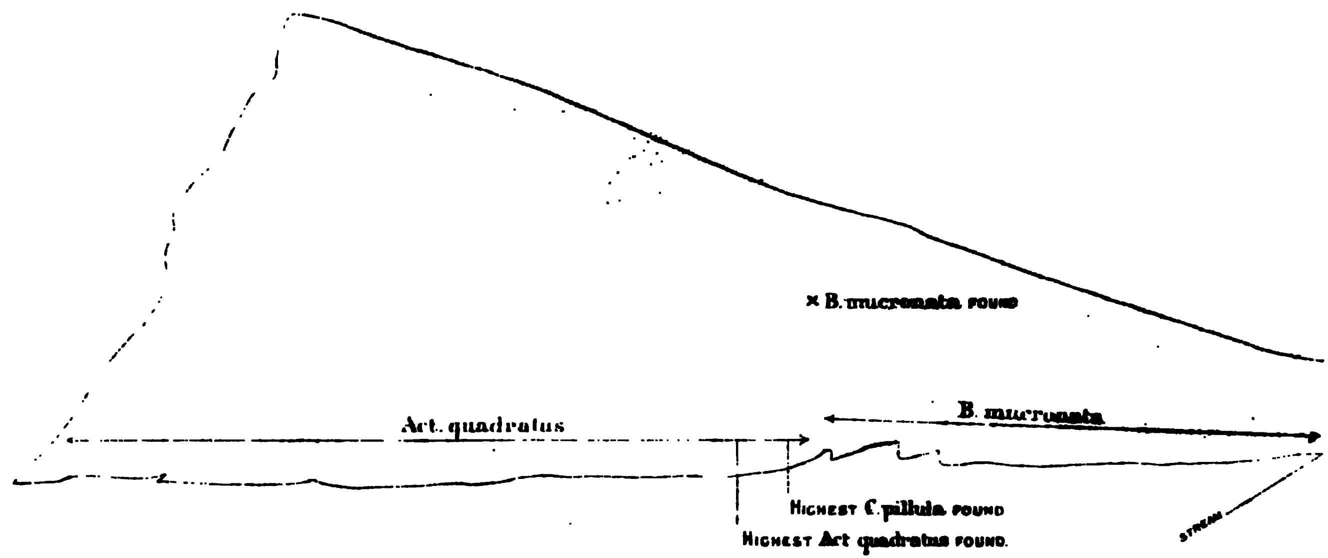
This poor little section, east of Black Rock, yielded a full *Marsupites*-fauna, for we got *Echinocorys vulgaris* var. *pyramidatus*, the nipple-shaped head of *Bourgueticrinus*, and ten examples of *Terebratulina rowei*.

The measurement of this zone, then, is . .	*Uintacrinus*-band . . .	17 ft.
	Marsupites-band . . .	12½ ft.
	Band containing neither *Marsupites* nor *Cardiaster pillula*	15 ft.

Zone of Actinocamax quadratus.

It may as well be said at once that from Barber's Rock to a point in the west side of Arish Mell, marked approximately by the boat on the shore in Pl. VI, we have only this zone to deal with. By taking the photograph from as near Cover Hole as the tide would permit, Prof. Armstrong has been able to give a good idea of the great extent of this zone. The southern face of Cockpit Head is, without exception, the best weathered and most fossiliferous that we have worked, not only in this zone, but in the whole Lulworth section. The reason is that the cliff is protected by a barrier of fallen blocks of chalk, which prevent the face from being pounded by the shingle. The section is not uniformly good, as in parts it is overgrown with sea-weed. The chalk is massive, white, free from marly veins and bands, but much slickensided and veined with calcite.

The contact with the *Marsupites*-zone occurs a few yards west of Barber's Rock, for opposite this convenient sea-mark we found two typical examples of *Act. granulatus* (*A. merceyi*), and three feet above them the first example of *Cardiaster pillula*. Another Belemnite



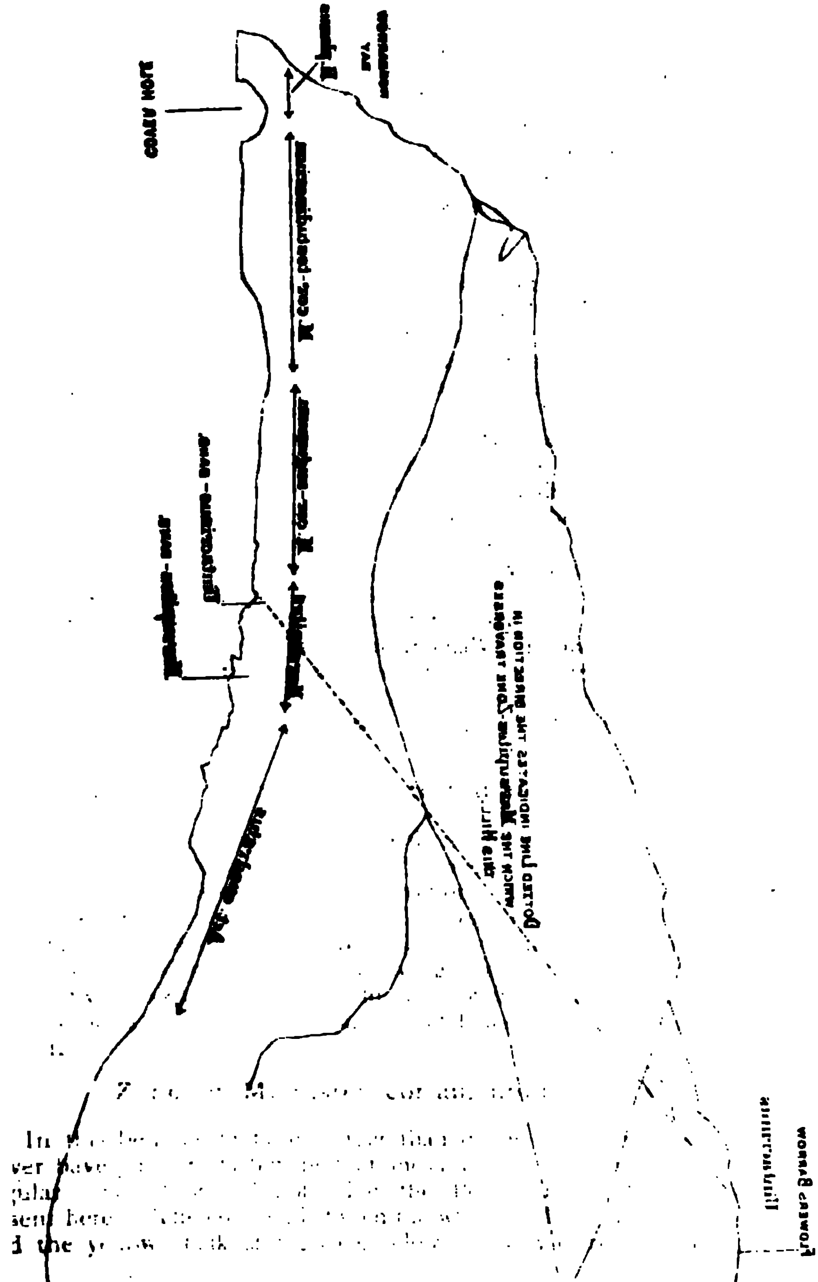
WEST SIDE ARISH MELL.

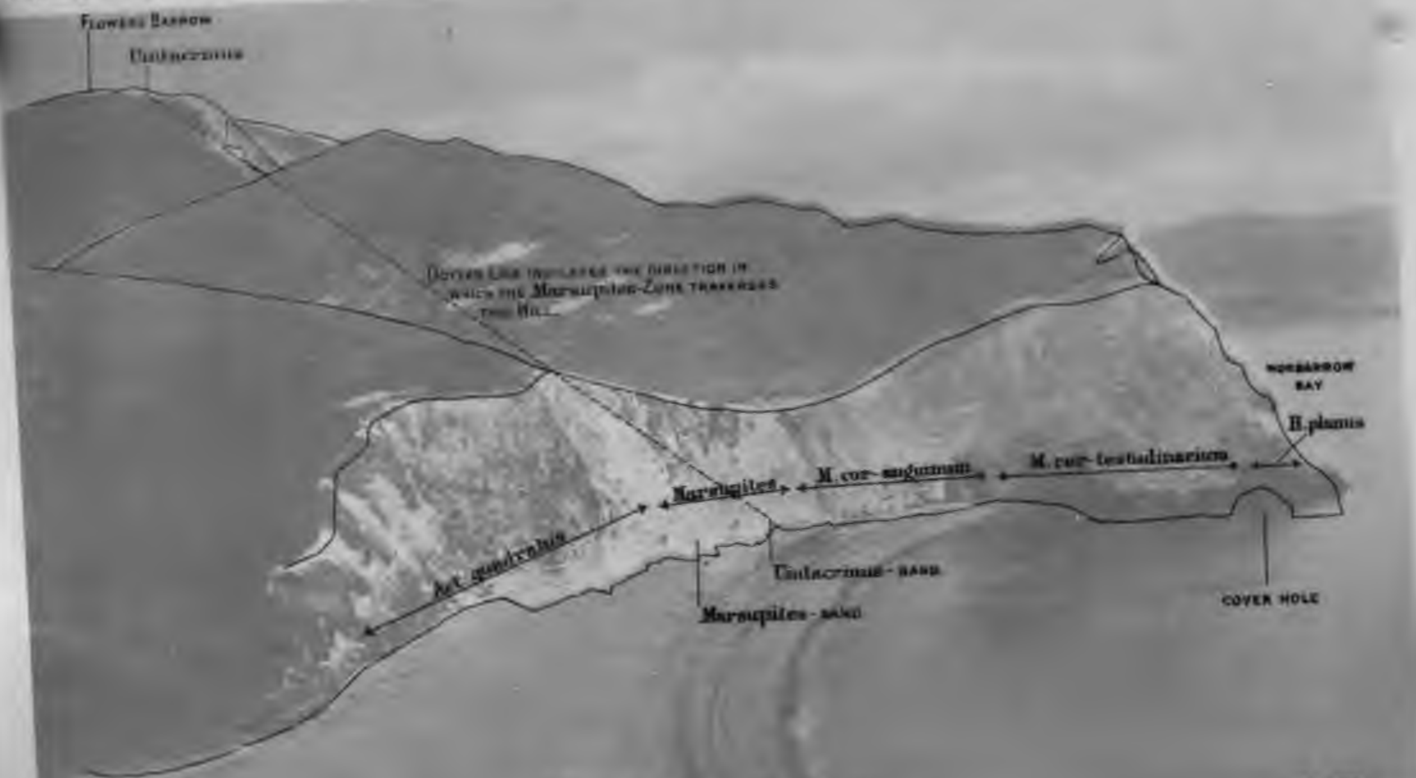
Pl. VI.

was found close to this spot, on a fallen block, but this was an undoubted example of *Act. quadratus*, and verified as such by Mr. Crick. These were the only Belemnites which this zone yielded at this particular spot, though in Arish Mell we found another *Act. quadratus*, which will be alluded to later on. The example of *Act. quadratus* on the fallen block proves that this fossil occurs here, and though we searched carefully for the narrow band which yielded them east of Middle Bottom, we failed to find it. It must be remembered that here the beds are inclined at a very high angle, and that if the narrow band in which *Act. quadratus* occurs were covered with sea-weed, or barren, at the base of the cliff, we should fail to find it. Several fine examples of *Terebratulina rowei* were found at the base of this zone near Barber's Rock. *Cardiaster pillula* is abundant in patches throughout this section, as it is in the bay between White Nothe and Bat's Head, and also on the Sussex coast. *Bourgueticrinus*, *Porosphæra*, and the Bryozoa are common and characteristic. *Echinocorys vulgaris* var. *gibbus* is found in profusion. The red colour of the Corals, Bryozoa, and Brachiopoda in this zone is as conspicuous as in Sussex.

As we approach the eastern corner of Cockpit Head the cliff is more overgrown with sea-weed, more wave-battered, and fossils are few and far between. It is this Point which we desire to warn the collector against, in the matter of the tide, for the water stands very high here. owing to the shelving beach. Rounding the corner into Arish Mell we find a splendid surface of vertical chalk facing due east. This is all in the *Act. quadratus*-zone up to the point indicated on Pl. VI. Fossils are exceedingly scarce here, and on our first visit we almost despaired of being able to determine the zones for that reason. Here the Bryozoa were our only guide. A subsequent visit, and more diligent search, enabled us to fill in the gaps yard by yard. A few feet below the junction with the zone of *B. mucronata* we found a fine example of *Act. quadratus*, with the largest granulations on the surface which we have ever seen. The granulations were so large that they deeply pitted the chalk in which the fossil lay, and we were by this means enabled to verify the exact spot of its occurrence by finding the impression in the chalk at a later visit, when accompanied by Mr. Teall. At the junction line we found a solitary example of *C. pillula*. We, therefore, have as undoubted evidence the fact that both *Act. quadratus* and *C. pillula* extend to the extreme upper limit of their zone in Dorset.

We measured this zone from opposite Barber's Rock to the point indicated in Arish Mell on Pl. VI, and found that it was 354 ft. thick. The measurement is very great, but so it was between White Nothe and Bat's Head, and it must be equally great at Ballard Head. Here we have the same physical difficulties to contend with, and we can only give these measurements in the





East side Arish Mell.

Pl VII

It will be noticed that the chalk in this obscure section is vertical, with the flints in position. The fauna is so complete and typical that we need only quote it to carry conviction that our determination of the zone is correct. We record the presence of the zones of *Act. quadratus* and *B. mucronata* in this section with considerable satisfaction, as their existence has hitherto been unsuspected. There are about 182 ft. of the *B. mucronata*-chalk exposed, from the point of junction with the *Act. quadratus*-zone to the sluice.

Barrois places the chalk on the western side of the bay in the zone of *Marsupites*. He did not find the plates of this fossil, but he records *Echinocorys gibbus*. The mere fact that *Echinocorys gibbus* was found would now suggest the zone of *Act. quadratus* and not that of *Marsupites*, for our work on the Sussex and Dorset coasts has placed the value of this fossil as a guide to the former zone beyond question. Barrois mentions that the Monastery Pit, not far from Arish Mell, is in the *B. mucronata*-zone.

The Arish Mell section is broken at the head of the bay by a small stream. Except in very dry seasons, good drinking water may be had from a small tributary stream, which gushes out at the foot of the cliff, on the western side of the sluice. We have mentioned the spring at Black Rocks, Lulworth Cove, and these are the only two which we know on this coast.

We now leave the western side of the bay, and start from Cover Hole, which is in greyish nodular chalk. From an examination of its southern face we know that it is in the zone of *Holaster planus*. We do not attempt to describe it, as it is inaccessible, and only a part of it exposed. We pass to the next zone.

Zone of Micraster cor-testudinarium.

This chalk is yellow, nodular, with irregular flint-lines. It affords one of the finest examples of slickensiding on the coast, the planes running in every possible direction. The spot at which we fix the junction with the zone of *M. cor-anguinum* is marked on Pl. VII. We obtained *M. cor-testudinarium* from this bed, but extensive collecting was impossible, owing to the headland being constantly tide-washed. We could not obtain a measurement, but it appears to be much the same as at Black Rock (about 50 to 60 ft.).

Zone of Micraster cor-anguinum.

In this bed the flints are larger than in the preceding, and never have pink crusts, but the flint-lines are more prominent and regular. The "zoning" noticed in the Beachy Head flints is absent here. The contrast between the white chalk of this zone and the yellow chalk of the zone below it is very marked. We here found *M. cor-anguinum* and its var. *latior*, *Echinoc* *conicus*, and the characteristic shape-variations of *Echinoi* *vulgaris*. Fossils are decidedly rare. We find that our note-l contains no mention of the thickness of this zone.

Zone of Marsupites testudinarius.

We obtain a zoological junction by working up the cliff ı we find the first *Uintacrinus*-plate. We fix the point and ma on Pl. VII. Working upwards, we collect abundant *Uintacri* plates for a thickness of 30 ft., when we find the first *Marsup* plate. After this we see no more plates or arm-ossicle: *Uintacrinus*, for they are replaced, in the usual way, by *Marsup* which is also well represented. The chalk yielding *Marsu* measured 24 ft., so that we have a combined measurement these two bands of 54 ft. As in the other sections we fi space above the *Marsupites*-band which is devoid of *Marsupites* *Cardiaster pillula*. This space, taking it from the last *Marsu* plate to the first *C. pillula*, measured 15 ft. This would gi thickness for the whole zone of 69 ft. Numerous example: *Terebratulina rowei* were found in both bands, and we obtained *Echinocorys vulgaris* var. *pyramidatus*, *Micraster* *anguinum*, *Echinoconus conicus*, and the nipple-shaped heac *Bourgueticrinus*.

Here the flints are of the same colour as some of thos the zone above, having pink cortices, differing from those at W Nothe, where they have grey crusts. This is another exampl the fallacy of attempting to zone chalk by the appearance of flints, and we pointed out the same discrepancies on the Su: coast. If we had no fossils to guide us there might be sc excuse for depending on flints; but even on this coast we always get sufficient zoological evidence.

Zone of Actinocamax quadratus.

The point of junction of the *Marsupites*-zone with that *Act. quadratus* is marked on Pl. VII, and was fixed at the situal where the lowest *Cardiaster pillula* was found. This was 15 ft. ab the last *Marsupites*-plate, so we get a fairly close junction. Belemnites were found here, but *C. pillula* was moderal common. As this is obviously but a small part of the zone did not measure it. Most of the flints in this particular sect have white cortices, but some of them show a pink tinge. *B. mucronata*-chalk is exposed on the east side of the stream.

WORBARROW BAY TO COVER HOLE.

There is a path leading from Arish Mell to Flower's Barr It is well worth the climb, for from the top we obtain a fine i of the trend of the beds. At the S.E. corner of the Barrow we found an exposure in the zone of *M. cor-anguinum*, from which we obtained several fine examples of *M. cor-anguinum* and the var. *latior*. There are two other bluffs at the top of the cliff, but they are not accessible, so we did not attempt to zone them. Just inside the inner wall of the castrum, in its western half, we see a small slipped face of chalk, running W.S.W. to E.S.E. From this we obtain *Uintacrinus*, the nipple-shaped head and barrel-shaped columnar of *Bourgueticrinus*, and *Terebratulina rowei*. Passing to the western end of the castrum, along this face, we can prolong our line of *Uintacrinus*-chalk to Arish Mell, which lies below us, and we find that this line comes out at the exact spot where we obtained this fossil in the bay below. But if we attempt to prolong the line to a spot east of Black Rock, where *Uintacrinus* was found, we see the twist in the beds which is indicated on Barrois' excellent map, and in that furnished by Mr. Sherborn.

We now retrace our steps to the east side of the Barrow, and descend the hill for some distance till we reach a path which takes us to the large sloping surface under the castrum. By descending the slope we can make our way to the shore, but we must choose our path with some care, as there are several morasses in which one could easily get mired. On the way down we can collect from fallen blocks from the zones of *H. planus*, *M. cor-testudinarium*, and *M. cor-anguinum*. We walk to Cow Corner, and on the way can work the fallen blocks, which are chiefly from the zones of *H. planus* and *M. cor-testudinarium*. No richer collecting is to be obtained on this coast from these two zones than that yielded from these fallen masses. Having arrived at Cow Corner, we face towards the east and see the beds, from Upper Greensand to the zone of *M. cor-anguinum*, raking down towards us. In the distance, at the far end of the slip, we can see the Upper Greensand and zone of *H. subglobosus* very plainly. In the shore-section the Upper Greensand forms an outer wall, as it were, just as at Durdle Cove, St. Oswald's Bay, and Mupe Bay, as indicated in Pl. II.

We shall not take the zones *seriatim* here, as we cannot measure them or collect properly from them. At Cow Corner we see magnificent ledges in the *R. cuvieri*- and *T. gracilis*-zones, but they are strangely unfossiliferous. From the former, however, we collected *Inoceramus labiatus*, *Rhynchonella cuvieri*, and *Discoidea dixoni*. The thickness of the *R. cuvieri*- and *T. gracilis*-zones appears to be greater here than in the other sections in the vertical chalk, but the situation of the beds did not lend itself to measurement. On the 6-inch map (Dorset, sheet 55) we get a good idea of the way in which the beds run out as ledges along the tide-washed cliff between Cow Corner and Cover Hole. This section can only be examined from a boat, and when we were there the sea was too rough to make the prospect attractive. As we row along the face covered with sea-weed for 10 or 15 ft. up the cliff. It is clear, then, that we shall probably fail in getting all our zonal junctions even if fossils are sufficiently numerous to enable us to do so.

As we near Ballard Point the beds become vertical, and we find that the tip and south side of Ballard Point are cut in the *H. planus*-zone.

Zone of Micraster cor-testudinarium.

Rounding the point we see a cave divided into two parts. The south side of the cave, which forms the north side of Ballard Point, is in yellowish nodular chalk, and from this we obtained *M. cor-testudinarium* and *M. præcursor* of the form characteristic of this zone. We were unable to measure this zone, but should hardly like to give it as much as 85 ft., which is the thickness mentioned by Barrois. In our estimation about half that thickness would be more correct.

Zone of Micraster cor-anguinum.

In the northern part of the cave the chalk is whiter, and clearly in the zone of *M. cor-anguinum*. We could reach no fossils here, so could not determine the zone from zoological data, though there would appear to be no doubt that the chalk is correctly assigned to this zone. Still passing northwards we round a little point, and enter another small bay. This also is in the zone of *M. cor-anguinum*. Then follows another small point, and we enter a bay of considerable size, with a shingle beach. The southern one-sixth of this bay is still in the same zone, so it would appear that we have a considerable thickness of this bed. We obtained from it a scanty but sufficient fauna to justify us in our determination of the zone of this chalk. Measurement is impossible here.

Zone of Marsupites testudinarius.

Still following the beds up we are able to define both the *Uintacrinus*- and *Marsupites*-bands by their name-fossils. Here the chalk is notably whiter, with fewer flint-lines. Fossils are very rare, and we considered ourselves very fortunate to distinguish any junctions at all. We also found *Uintacrinus* in little bare patches on the top of Ballard Cliff, close to the edge of the cliff. We could obtain no measurement of this zone which was accurate enough to be worth recording.

Zone of Actinocamax quadratus.

We then pass to a yellower and flintier chalk, which extends as far as Argyll Point. This Point is drawn on the 6-inch map, the cliff we see how the zone of *R. cuvieri* runs out as a long ge, and is replaced by another ledge in the *T. gracilis*-zone, and r this in turn is worn back until the grey flinty chalk with *H. nus* comes in. The whole of the last part of the cliff is cut in zone.

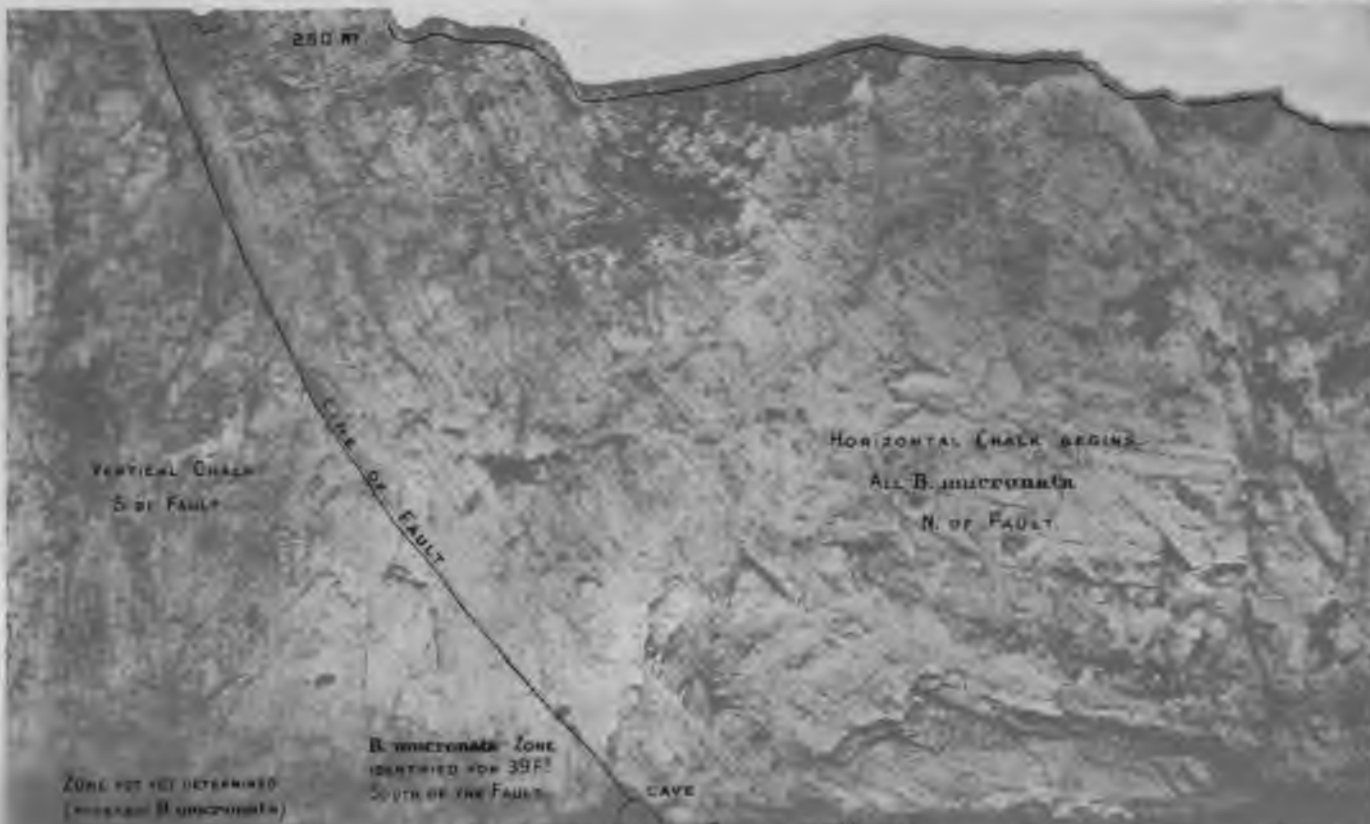
It is well worth while to take a boat from Worbarrow Bay to sh Mell, as it saves a long climb, and enables one to see the fine -washed cliff just mentioned.

BALLARD POINT TO STUDLAND BAY.

This section can be conveniently worked from Swanage, where re is no difficulty in obtaining excellent accommodation. One walk along the shore, at low water, nearly to Ballard Point, it was found much quicker to use a boat, for the whole section m Ballard Point to St. Lucas' Leap can be worked in no other y. This is unfortunate, for, unless the sea is calm, it is possible to land along the Foreland.

We note that the Upper Greensand begins on the south face "Ballard Cliff," at a point between the letter *d* of the first word, l the letter *c* of the second word, as printed on the 6-inch map orset, sheet 57). The beds are here inclined at an angle of 60°, l we trace in succession the Chloritic Marl, and the zones of *subglobosus*, *A. plenus*, *R. cuvieri*, *T. gracilis*, and *H. planus*. e last zone forms the tip of Ballard Point, and appears to be out 20 ft. thick. We can walk on the upturned edges of this lined chalk, as far as the zone of *T. gracilis*. We found it possible to get on any surface of the *H. planus*-zone, even from oat. The point on the shore where the junction of the *R. ieri*- and *T. gracilis*-zone occurs, is marked by the wire fence ich comes over the top of the cliff. We landed near Ballard int on the *T. gracilis*-beds, and found a wonderfully air-athered section. The double band of yellow-green nodules e Chalk Rock of the Geological Survey) is here well developed l is, as in all other sections on this coast, well down in the *gracilis*-zone. This cliff-face was studded with fossils, and it is only exposure in this zone which yielded a good list. We ained on this small face thirty-five species. From among m we record: *Cidaris serrifera*, *Pentacrinus agassizi*, *Discoidea oni*, *Hemiaster minimus*, *Cyphosoma radiatum*, *Holaster nus*; *Terebratulina gracilis*, *Rhynchonella cuvieri*, *R. reedensis*; *ceramus cuvieri*, *I. brongniarti*, and *Turbo gemmatus*. We also nd a splendid frond of *Homœosolen ramulosum*, and several cks of *Diastopora oceani*.

Before we attempt to zone the chalk south of the Ballard ust-fault we row along the section in a boat. We at once note t we have grave difficulties before us, as certain spots are ccessible, even at low tide, and others which are accessible are



THE THRUST-FAULT, BALLARD HEAD.

but is not named. It was by landing on Argyll Rock that Prof. Armstrong, after many disappointments, and much weary waiting, secured the photograph of the thrust-fault (Pl. VIII). Towards the northern end of this bay we trace two yellow nodular bands, which run out almost due east as a ledge terminating in a rock. These bands are strangely reminiscent of the Chalk Rock of the Geological Survey. Close to the point at which the ledge leaves the cliff we were fortunate enough to find two very battered examples of *Act. quadratus.* They were too much damaged to allow of exact determination, but it is certain that they were not *B. mucronata.* They could only, therefore, be *Act. quadratus* or *Act. granulatus* (*A. merceyi*). The distance from the junction with the *Marsupites*-band excludes the possibility of their being referred to the latter. Much fresh water constantly drips from the vertical chalk in this part of the bay, and our boatman told us that, in a dry summer, when all other dripping springs dried up, this one still persisted. Throughout the whole of this long extent of *Act. quadratus*-chalk we found no example of *C. pillula.* In fact, the whole of the chalk which we assign to this zone was barren to a degree unprecedented in our experience. But for our definite knowledge of the contact with the *Marsupites*-band, and the presence of the two examples of *Act. quadratus*, we should have been completely adrift. Possibly on a second visit we might be more fortunate in finding fossils.

Passing round Argyll Point we enter another little bay, with springs dripping from the cliff. Here again we found absolutely no zonal fossil. In this bay we saw some very large solid flints, of a brownish colour, which reminded us strongly of the columnar masses of flint which we saw in the pit south of Tyneham, on the Chalk Ridge. This pit was in the zone of *B. mucronata*, for we found *Magas pumilus* but no Belemnite. In the case of this bay, however, we found no zoological evidence whatever to justify us in placing it in the *B. mucronata*-zone. We, therefore, for want of better evidence, refer the chalk in this bay to the *A. quadratus*-zone. We may remark that we found the top of this zone at Arish Mell almost equally devoid of fossils.

With the exception of this little bay we can work no more of the face of the cliff until we come to the fault, for the cliffs are obscured by sea-weed to a height of 15 ft. The only way to zone this chalk would be to work it with a ladder, and we regret that the one which we took with us was too short for the purpose.

It will be seen from this description that we have here a wide extent of chalk, based by a definite contact with the *Marsupites*-zone, and clearly not in the *B. mucronata*-zone. Had it been in the latter we must have seen examples of the name-fossil, which is found in abundance on the north side of the fault, close up to the curve. It is evident that whatever the thickness of the *A. quadratus*-zone may be, it must be very considerable, thus, in some degree, justifying the large measurements of this zone which we obtained at Middle Bottom and Arish Mell.

That the *Act. quadratus*-zone does not extend up to the fault is quite clear from the fact that we found a fine example of *B. mucronata* above the sea-weed line, 39 ft. south of the fault; and in the cave, which the sea has eaten out in the line of weakness caused by the fault, we found two examples of the small *Echinocorys*, shaped like an *Echinoconus*, which we found in the same position at Arish Mell, and regard as characteristic of the lower part of the *B. mucronata*-zone.

Dr. Barrois places the chalk on the south side of the fault in the "Zone à Belemnitelles," but assigns that on the north side of the fault to the zone of *Marsupites testudinarius*. He gives no zoological reasons for putting the chalk on either side of the fault into the zones indicated. While we find no mention in his text that he found *B. mucronata* chalk on the south side of the fault, his diagram (*op. cit.*, Pl. III, fig. 7), leaves no doubt upon the point. We now know that his supposition of *B. mucronata* chalk on the south side of the fault is substantiated, but that there is no ground whatever for placing that on the north side in the *Marsupites*-zone. Indeed, it is difficult to see how he could have entertained the latter idea at all, for the whole cliff, from the fault to Studland Bay, is cut in the *B. mucronata*-zone, rich in the name-fossil, and in all other characteristic fossils associated with it, and at the time of our visit perfectly exposed and accessible in its entire extent.

From Ballard Point to the fault we have, then, nothing but vertical chalk, ranging from the *H. planus*-zone to that of *B. mucronata*. The chalk is hardened and altered to a remarkable degree; it breaks with a conchoidal fracture, is much slickensided, and even the flints are crushed and shattered. On this point Mr. Strahan writes*: "Under the microscope many perfect foraminifera can be detected, showing that though there has been reconstruction and cementing, the rock has not been perfectly crushed." And he adds, after comparing some analyses of the chalk, "They serve to show, however, that the chemical composition of the hardened chalk along the line of fault is almost identically the same as that of the chalk which has not been thus altered. The hardening seems to have been due to the rock having been compressed beyond its crushing point, and subsequently cemented by calcite, a process which would leave the chemical composition of the mass unchanged."

From Ballard Point to the fault the distance is 1,200 ft., according to Mr. Strahan. We give an extract from the description of the fault by this writer. He says (p. 169) "The fault itself forms a very sharp line, curving upwards in the cliff with beautiful regularity, and keeping exactly parallel to the bedding planes of the beds above it. These strata curve up through nearly an

* "Geology of the Isle of Purbeck," *Mem. Geol. Sur. Eng. and Wales* (1898), p. 168.

eighth of a circle, so as to be nearly vertical at the top of the cliff, while at the foot of the cliff they dip northwards at an angle of about 40°. Through the whole curve they rest on the edges of vertical chalk, with a curiously close imitation of a great unconformity." This description is so good that we prefer to give it *in extenso*, and the features described therein are well brought out in Pl. VIII. We would refer the reader also to Chapter XV. of Mr. Strahan's Memoir for a summary of the other physical phenomena of the district.

We see that the fault has taken place in the zone of *B. mucronata*, and that it runs out, east of Middle Bottom through the zone of *Act. quadratus*.

Leaving the fault we pass northwards, and save for a few points at which the cliff is clad in sea-weed, or battered by the sea, we have a rich cliff-section in *B. mucronata*-chalk, $1\frac{1}{3}$ miles in extent. Nowhere on the English coast is this zone so admirably exposed as here. The beds, horizontal at first, dip gently to the north at about 10° as we approach Handfast Point. The chalk shows but little trace of alteration, but we notice a few small faults and occasional slickensiding. Some of the flints are cracked, but on the whole they are fairly intact, running in irregular lines. Sometimes the flints are very large, especially in the highest beds in Studland Bay, but there are no "pot-stones" like those seen at Runton or in the Norwich Chalk. We no longer see veins of calcite, and though the conditions have greatly improved, the chalk differs greatly from that in the horizontal beds around Wool. Inland, the chalk can be crushed between the finger and thumb; on the coast, it has been compacted considerably, for while we can cut it with a chisel, it is anything but soft, and the cleaning of the fossils, if not actually impossible, is only effected with the greatest difficulty. All large fossils are broken, and a perfect Echinid is a great rarity. In the same way, Belemnites are frequently broken in several places, the fragments being considerably displaced.

But though it is most difficult to obtain good specimens from this chalk, it is possible to procure, even in a moderate time, a fair number of identifiable forms. The fauna will be discussed in detail in the zoological summary, and it will be sufficient to say now that it differs in no important way from the normal.

It will come as a surprise to some that we have here a coast-section in *B. mucronata*-chalk, which is at least 250 ft. thick. For the present we must ignore the *B. mucronata*-chalk on the south side of the fault, which we know to be at least 39 ft. thick, and begin our measurements at the fault itself. If we take a line from the cave at the foot of the fault so that it intersects the middle of the curve at right-angles, we find that it reaches a strong line of nodular flint. This flint-line is 100 ft. from the curve. We follow this strong flint-line, and find that it comes to the shore 100 yds. north of the first Pinnacle. At this point we see two yellow bands at the top of the cliff, the lower strong and constant, and the upper weak. The upper one dies out as we go north. There is roughly 100 ft. between the strong flint-line and the strong yellow band. This yellow band can be traced readily to Handfast Point, and Old Harry shows it well. It is about two-fifths up the cliff at Handfast Point, and gradually sinks as we pass into Studland Bay, till it reaches the shore on the west side of the fifth little headland west of Handfast Point. There is about 50 ft. of chalk above the yellow band in Studland Bay, so that we can obtain a thickness of *B. mucronata*-chalk (as exposed) of at least 250 ft. As far as we can tell, the measurements given are, if anything, under-estimated. We believe that this is the first time than an adequate estimate has been given of this zone on the Dorset coast, or that the approximate thickness has been gauged anywhere in the south of England.

CHALK PITS IN THE LULWORTH DISTRICT.

These are mostly very poor exposures, as very few are being worked. They fall naturally into two groups—(i) those in the horizontal chalk in the Wool area, and (ii) those in the vertical chalk along the Chalk Ridge. We take those in the horizontal chalk first:

(i) WOOL AREA.—HORIZONTAL CHALK.

Coombe Pit is one-third of a mile north of Coombe Keyne in the fork of the road from Wool to West Lulworth. It is a small exposure mentioned by Barrois,* and is rich in *Belemnitella mucronata*, *Magas pumilus*, and *Rhynchonella limbata*. We found there *Crania costata*, *Pecten cretosus*, as well as *Terebratula carnea*, *Rhynchonella plicatilis*, *Kingena lima*, and *Ostrea vesicularis* of the forms characteristic of the zone. No perfect *Echinocorys* was found, but spines of *Cidaris serrata* were present. This pit was being worked in 1899–1900.

Dorset Pit is five-sixths of a mile north-east of Coombe Pit, and is also mentioned by Barrois.* There is no road to this pit, and we can only reach it by going across private land. The fauna is the same as in Coombe Pit. This pit was being worked in 1899-1900.

Burton Pit is one mile north of Coombe Pit, and is also mentioned by Barrois.* This is the largest exposure of the series, and was being worked in 1899-1900. The fauna is the same as in Coombe Pit.

Pug Pit (not named on the 6-in. map) is 300 yards north-east of Burton Pit, and is on private land. It is very small and unworked. We found *Belemnitella mucronata* there.

Coffin Pit is another small unworked exposure, not named on

* *Op. cit.* (p. 98).

the 6-in. map. It lies half-a-mile south-east of Burton Pit, and is on private land. *Belemnitella mucronata* was found there.

In all these pits the chalk is soft and rather yellow, and the bedding horizontal. The flints are not in regular bands, and are black with very thin fawn-coloured crusts. Many of these are very small and shaped like Belemnites.

(ii) CHALK RIDGE.—VERTICAL CHALK.

We had no time to zone all the pits along the Chalk Ridge, and could only examine such as were near Arish Mell. All these were in vertical *B. mucronata*-chalk, and none are systematically quarried. The chalk is intensely hard, and can be trimmed with a hammer, like a flint.

Monastery Farm Pit is one-sixth of a mile south of Monastery Farm, and is mentioned by Barrois.* It yielded *B. mucronata* to him, but we only found *Magas pumilus* and *Pecten cretosus*. It is a poor section, and fossils are very rare.

A small unnamed pit, 300 yards south-east of Boat Knoll, contained *Magas pumilus* but no *Belemnitella mucronata*. Fossils were rare.

Whiteway Pit, a small exposure south of the farm of that name, only yielded *Magas pumilus*. This pit is not named on the 6-inch map.

A small pit, south of the letter *n* in Tyneham, also gave us *Magas pumilus* but no *Belemnitella mucronata*. In this pit were remarkable columnar masses of flint running down the face of the pit and across its floor. They were strongly reminiscent of the Norwich pot-stones. They measured a foot across, but showed no evidence of a central core.

Long Close Bottom Pit, also unnamed on the 6-inch map, is situated north of the letter *m* in Tyneham. This also contained *Magas pumilus*.

It will be seen that no Belemnites were found in these pits, although we searched carefully for them. This is remarkable, as they are so common along the coast section.

All the pits figured on the 6-inch map from White Nothe to Lulworth are grassed over. We did not visit the pit in the *Marsupites*-zone, mentioned by Barrois as lying north of the coastguard station at White Nothe, nor do we know if there is any exposure there. We found *Marsupites* and *Uintacrinus* at the top of the cliff, 100 yards east of the signal, and that was sufficient evidence for us.

LITHOLOGICAL SUMMARY.

It will be seen that, even in the horizontal chalk on the coast, the rock is harder than usual, and fossils more difficult to extract

* *Op. cit.* (p. 98)

From the whole White Nothe section we hardly obtained a foss which could be properly cleaned. We have alluded to the natur of the chalk in the horizontal *B. mucronata*-zone at Ballard Heac and refer the reader to p. 59 for further details. Owing to th profound alteration of the beds within the area of the vertic chalk, it is difficult to define their lithological features concisel or to draw a fair comparison between the Dorset zones and thos in Kent and Sussex.

Zone of Rhynchonella cuvieri.

This zone contains one band of nodular flint at about th junction with the zone above it. It is a hard, nodular chal conforming fairly accurately with the general characters of this zon There is no Melbourn Rock or Grit Bed, but *Inoceramus labiatus* i commoner at the lower part. In this it resembles the *R. cuvier* zone at Beachy Head; while at Dover the Grit Bed is splendidl developed.

Zone of Terebratulina gracilis.

This zone is so altered that it is difficult to compare it wit other sections. It is practically flintless, and contains marl-band which do not, however, weather-out in open seams. The *T. gracili* chalk at Beachy Head is flintless; but at Dover it contains sever strong lines of nodular flints.

Zone of Holaster planus.

The greyish colour of this bed in Dorset, from admixture wit marl, forms a very useful rough indication of its presence. Yello bands of nodular chalk are scattered through it, but we fail to fi any evidence of a true Chalk Rock in its lithological sense. It a flinty chalk, and the lines of flints are irregular. It resembl the same zone in Sussex in that there is no lithological zoological Chalk Rock. In Kent, it will be remembered, t latter bed is strongly represented in its zoological sense, though is absent lithologically.

Zone of Micraster cor-testudinarium.

A flinty chalk, with irregular bands of yellow nodular chal The flint-lines are more crowded and irregular than in the *M. c anguinum*-zone. The whole bed is of a reddish colour, and t enables one to define it at a distance. It conforms fairly close with the same zone in Kent and Sussex.

Zone of Micraster cor-anguinum.

This bed also follows the usual characteristics of the zone Kent and Sussex, for the flints, both tabular and nodular, run even lines. The chalk, however, differs from the normal in that it contains areas which are strongly iron-stained. Yellow nodular bands pass up from the zone of *M. cor-testudinarium* into the base of this zone, and in this it resembles the conditions found on the Sussex coast; while at Dover the line of demarcation between the two zones is very sharp.

Zone of Marsupites testudinarius.

The chalk of this zone resembles that of the Sussex coast in that irregular flint lines are common. The Thanet chalk, it will be remembered, is, with the exception of the "Bedwell-line," practically a flintless chalk.

Zone of Actinocamax quadratus.

Flint bands, both tabular and nodular, are abundant, and in this it resembles the *Act. quadratus*-chalk of the Sussex coast, though tabular bands are less common here. It has a further resemblance for the reason that the chalk is of a marly nature. The marl is not intimately mixed, as in the *H. planus* zone, but the chalk is traversed by minute veins of it. For this reason the chalk preserves its usual white colour.

Zone of Belemnitella mucronata.

Both in the soft horizontal beds at Wool, and in the harder chalk at Ballard Head and Studland Bay, we have many irregular lines of nodular flint. In Studland Bay, especially in the higher part of the zone, the flints are often of large size, but they never assume the shape of pot-stones, as at Runton and Norwich. It has been noted, however, that in a small pit on the Chalk Ridge (p. 39), we found large columnar masses of flint, and that two somewhat similar flints were seen, south of Ballard fault, in chalk of doubtful origin, but which we refer to the *Act. quadratus*-zone.

FLINTS.

When we began to work this coast we took careful notes of the nature of the flints in each zone, partly with a view to checking Barrois' observations, and partly to see if they afforded any reliable guide to horizon. After making many observations, we found that the colour of the flints, or rather of their cortices, varied greatly even in the same zone, and that within a limited area. We were not unprepared for this, as exactly the same thing occurred in Sussex. Barrois, at the time that he visited this coast, attached considerable importance to the flints as an index of horizon, but we have shown that he has since modified his views. That he was misled by them in fixing his *Marsupites*-zone was obvious. We, therefore, give no summary of the appearances of the flints, as we believe that it would be waste of labour to do so.

MEASUREMENTS.

We have repeatedly alluded to the difficulty of obtaining accurate measurements within the area of vertical chalk—a difficulty which is increased by the comparative rarity of fossils. This fact renders the determination of zonal boundaries a very arduous task. We have noted, moreover, the remarkable variations of zonal measurements in situations which are closely associated, and for this reason we give a summary of measurements for the coast, taking them in the same order as they are recorded in the text. In several instances the measurements are actually contradictory, and much as we regret this fact, we prefer to give them as we made them, rather than try to make them tally with the figures which our preconceived ideas would suggest.

White Nothe to Bat's Head.

(White Nothe to Middle Bottom.)

		Ft.
Rhynchonella cuvieri-zone		76
Terebratulina gracilis-zone		58
Holaster planus-zone		51
Micraster cor-testudinarium-zone		113
Micraster cor-anguinum-zone		171
Marsupites testudinarius-zone	*Marsupites*-band, 30; *Uintacrinus*-band, 81	111
Actinocamax quadratus-zone		254 (exposed)

(Bat's Head to Middle Bottom.)

		Ft.
Holaster planus-zone		15 (exposed)
Micraster cor-testudinarium-zone		110
Micraster cor-anguinum-zone; *Marsupites testudinarius*-zone	combined	205
Actinocamax quadratus-zone		323 (exposed)

Durdle Cove to Bat's Head.

	Ft.
Rhynchonella cuvieri- and *T. gracilis*-zones combined	70
Holaster planus-zone	10 (exposed)
Micraster cor-testudinarium-zone	70
Micraster cor-anguinum-zone	240

Man-o'-War Cove.

	Ft.
Rhynchonella cuvieri-zone	45
Terebratulina gracilis-zone	40
Holaster planus-zone	25

St. Oswald's Bay.

	Ft.
Rhynchonella cuvieri-zone	72
Terebratulina gracilis-zone	29
Holaster planus-zone	15-20
Micraster cor-testudinarium-zone	68
Micraster cor-anguinum-zone	—

MUPE BAY.

Rhynchonella cuvieri-zone	49
Terebratulina gracilis-zone	29
Holaster planus-zone	49½
Micraster cor-testudinarium-zone	50-60

BLACK ROCK TO ARISH MELL.

Micraster cor-testudinarium-zone		50-60
Micraster cor-anguinum-zone		193
**Marsupites testudinarius*-zone	*Uintacrinus*-band, 17; *Marsupites*-band, 12½	29½
Actinocamax quadratus-zone		354
Belemnitella mucronata-zone		182 (exposed)

ARISH MELL.

Holaster planus-zone		20 (exposed)
Micraster cor-testudinarium-zone		50
Micraster cor-anguinum-zone		—
**Marsupites testudinarius*-zone	*Uintacrinus*-band, 30; *Marsupites*-band, 24	54

BALLARD POINT TO STUDLAND BAY.

Zones from *Holaster planus* to *Actinocamax quadratus* are impossible to measure with accuracy	—
Belemnitella mucronata-zone	250 (exposed)

ZOOLOGICAL SUMMARY.

We shall follow the methods employed in the Kent and Sussex paper, and give a tabular summary of the zonal guide-fossils. It must be understood that each summary applies only to the Dorset coast, though, where possible, comparisons will be drawn between this coast and those of Kent and Sussex. It is felt that comparisons such as these will at the same time bring out the wonderful way in which zonal guide-fossils hold good over wide areas, and the equally interesting local variations in geographical distribution.

Zone of Rhynchonella cuvieri.

As we have before said, there is no Grit Bed here, and our summary, therefore, must be one for fossils common throughout the zone.

In Dorset this is a poor zone for fossils, and such as are found are generally badly preserved.

Inoceramus labiatus	throughout the zone.
Rhynchonella cuvieri	
Discoidea dixoni	

* We give the measurements of the bands actually containing *Uintacrinus*- and *Marsupites*-plates. For remarks on this point, see pp. 25, 30.

Other characteristic fossils are: *Echinoconus subrotundus*, *Echinoconus castanea*, *Cidaris hirudo*, *C. serrifera*, and *Hemiaster minimus*.

Rhynchonella cuvieri and *Inoceramus labiatus* are both abundant throughout the zone, as they are in Kent and Sussex; but the latter fossil is more abundant at the base, where it runs to a large size.

Discoidea dixoni is also abundant throughout the zone, being about as common as at Beachy Head, but by no means reaching the profusion in which it occurs at Dover.

Cardiaster was represented by a single very large example, probably not *C. pygmæus*, and resembling the form found at Bee Head. Only one example of *C. pygmæus* was found at Beach Head, while it is very abundant at Dover.

Echinoconus subrotundus is rare here, as at Beachy Head, an as in the latter locality is not restricted to the base of the zone. Dover, on the other hand, it is a common fossil, and is general found in the Grit Bed, or just above it. The two examples foun in Dorset were met with near the top of the zone.

Echinoconus castanea is represented by a single example, we up in the zone. It was not found at Beachy Head; but at Dov it is moderately common, always occurring in the base of the zon

Glyphocyphus radiatus and *Ammonites peramplus* were n found here, though they occur at Beachy Head and Dover. O the other hand, one example of *Ammonites cunningtoni* was found Lulworth Cove, and not in the other two localities.

Cidaris hirudo and *C. serrifera* are fairly common here, a are found in about the same abundance in Kent and Sussex.

Hemiaster minimus is rare here and at Beachy Head, a more common at Dover. In these sections it is always of sm size.

A *Serpula* always attached to *Inoceramus labiatus*, and unl any figured form with which we are acquainted, has been fou by us in all three counties. It is almost invariably found colonies and not singly.

Zone of Terebratulina gracilis.

Terebratulina gracilis / *Inoceramus labiatus*	throughout the zone.
Micraster cor-bovis . .	in upper part of zone.

Other characteristic fossils are: *Pentacrinus*, *Discoidea dix*, *Hemiaster minimus*, *Holaster planus*, *Cyphosoma radiat*, *Cidaris serrifera*, *C. hirudo*, and *Rhynchonella cuvieri*.

Terebratulina gracilis and *Inoceramus labiatus* are comm throughout, in the same manner as at Dover and Beachy Hea

Micraster cor-bovis is commoner than at Beachy Head, a rarer than at Dover. It only occurs here towards the top of t zone. One example of the *M. præcursor* group was found about 25 ft. from the top of the zone, with well-marked "sutured" ambulacra.

Pentacrinus is not very common, as at Beachy Head; while at Dover it is more abundant.

Holaster planus, *Discoidea dixoni*, and *Hemiaster minimus* are rare here and at Beachy Head, and commoner at Dover.

Echinoconus subrotundus is equally rare in all three counties. We found it here at the base of the zone only. Here again, as at Beachy Head, the base of this urchin was flatter than usual.

Cidaris serrifera, *C. hirudo*, and *Rhynchonella cuvieri* are fairly abundant in each county. *Cyphosoma radiatum*, so common at the top of this zone at Dover, is rare here and at Beachy Head.

The sponges, particularly *Craticularia fittoni*, *Guettardia stellata*, and *Cephalites*, are poorly represented. This is equally notable at Beachy Head, while at Dover they form quite a feature of the zone.

Inoceramus brongniarti and *Turbo gemmatus* were each represented by a single example. They were rare also in Kent and Sussex. *Holaster placenta* was not found here. It was rare at Beachy Head, and rather common at Dover. At Ballard Head we found several large masses of *Diastopora oceani*, which is to us a new record for this zone.

Zone of Holaster planus.

Holaster planus
Micraster præcursor } of group-form pecu-
M. cor-testudinarium } liar to this zone.
M. cor-bovis
M. leskei
Echinocorys vulgaris var. *gibbus*
Pentacrinus agassizi
Terebratula carnea
Pleurotomaria perspectiva
Turbo gemmatus
} throughout the zone.

Other characteristic fossils are: *Cidaris serrifera*, *C. clavigera*, *Cyphosoma radiatum*, *Salenia granulosa*, *Holaster placenta*, *Terebratulina gracilis*, *T. semiglobosa*, *Rhynchonella plicatilis*, *R. cuvieri*, *Crania egnabergensis*, *Inoceramus brongniarti*, *Inoceramus* sp., and Bryozoa.

The bracketed fossils are found in much the same proportions in Dorset and Sussex. The same fauna occurs at Dover, but in much greater profusion.

Cidaris serrifera and *C. clavigera* are here found in about equal proportions. At Dover, *C. serrifera* is the dominant fo while at Beachy Head *C. clavigera* takes its place. We a found *C. sceptrifera* here, but it was not common.

The Brachiopoda conform to the general rules of the zo as mentioned in the paper on Kent and Sussex (*op. cit.*, p. 31 and *T. carnea* is as common here as elsewhere, and equ reliable as a zonal guide.

Inoceramus sp.* was found here, as well as *I. brongnia* The former was referred to in the Kent and Sussex pa (*op. cit.*, p. 314). It is evidently a useful guide-fossil.

Plicatula barroisi, so abundant at Dover, was rather rare h and at Beachy Head.

There is no zoological Chalk Rock in Dorset, but we generally count on finding *Pleurotomaria perspectiva* and *Ti gemmatus* in this zone. We found the former in every expos of this zone in Dorset, but the latter was limited to a sin occurrence at Man-o'-War Cove. No Cephalopoda were seen

Bryozoa are poorly represented, but *Eschara acis* and *Reticulip obliqua* were found. The chief discovery was that of the beaut little Bryozoon called *Defrancia* in the Museum of Practical Geolo Jermyn Street. This has been described by Prof. J. W. Greg in the MS. of his second volume of "Cretaceous Bryozoa." I found in the same zone at Arreton, Isle of Wight. We co hardly expect to get good Bryozoa in this inhospitable rock.

Serpula ilium is moderately common, as at Beachy Head. Dover it is found in profusion. *Pentacrinus*, *Cyphosoma radiat Holaster placenta*, and *Salenia granulosa* are moderately comm here and at Beachy Head, but abundant at Dover.

In the case of *Micraster* it may be mentioned that every feat of the essential details of the test, claimed as characteristic of zone in Kent and Sussex, is brought out here with unswerv accuracy. These features could be relied on even in the m unpromising sections in this altered chalk, and we never had least difficulty in assigning fallen blocks to this zone.

It may be of service to summarise our knowledge of the Ch Rock, as brought out by the examination of the coasts of K Sussex, and Dorset.

Kent, zoological only, but characteristic fauna very abundant.
Sussex and Dorset, neither zoological nor lithological.

The so-called Chalk Rock of the Geological Survey is fo here well within the zone of *T. gracilis*, varying, according to compression on the rock, from 10 to 20 ft. from the base of *H. planus*-zone. That this is the case can be ascertained anyone who will carefully collect from the beds in question, fix junctions by zoological data, and not by a variable

* Henry Woods, "The Mollusca of the Chalk Rock," *Quart. Journ. Geol. Soc.*, vol. May, 1897, plate xxvii, figs. 14, 15.

unreliable lithological feature. That bands of yellow-green nodules are not restricted to the *H. planus*-zone may be inferred from the fact that we found one, practically identical in appearance with the so-called Chalk Rock of the Geological Survey, south of Argyll Point, in the *A. quadratus*-zone. As fossils are conspicuous by their absence at this point, the possibilities of faulty zoning through clinging to a mere lithological feature are too obvious to need further comment.

It would seem that the time has come for defining the value of this very variable and uncertain bed. In districts where it is well-developed lithologically it is an important aid in mapping, and should receive its true and unquestioned value. Equally, in other areas where it does not occur, it is unwise to drag it in, for it is useless to the cartographer, and misleading to the geologist. Let us, in any case, at least confine it to the *H. planus*-zone. If a band of green-coated nodules occurs out of this zone, let us indicate it as "a band of green-coated nodules" only, and not call it Chalk Rock; for all experience points to the *H. planus*-zone as the only horizon at which we can hope to find the peculiar fauna which is sometimes associated with this somewhat inconstant lithological feature.

Zone of Micraster cor-testudinarium.

There is only one clear section of this zone, and that is at White Nothe, in the horizontal chalk; but this exposure is so barren, from top to bottom, that one can hardly believe that one is in this generally prolific zone. The lack of fossils is largely due to the cliff being so pounded by the shingle. Other sections are either constantly tide-washed, or too fragmentary to be of any real use. We, however, obtained a perfectly characteristic, though scanty, fauna.

Micraster præcursor / *Micraster cor-testudinarium*	of group-form characteristic of the zone.	throughout the zone.
Echinocorys vulgaris var-*gibbus*		

Other characteristic fossils are: *Cidaris clavigera*, *C. serrifera*, *Holaster placenta*, and *Serpula ilium*.

Plicatula barroisi, so abundant at Dover, was not found, and *Serpula ilium* is comparatively rare. The latter fossil is found in profusion at Dover, but is rarer at Beachy Head and Seaford Head. Bryozoa were conspicuous by their absence. We note this fact because we look upon this as one of the richest zones for these beautiful forms. Owing to the scanty fauna of this zone it is useless to compare it with that of the same zone in Kent and Sussex. We, must, however, state that *Micraster* in every way conformed to the general rules for the essential features of the test, as indicated on pp. 512, 513, of the paper on *Micraster*.*

* "An Analysis of the Genus Micraster," *Quart. Journ. Geol. Soc.*, vol. lv, 1899.

The ambulacra, as in Sussex, were nearly always of the "sub-divided" form; but what is of perhaps greater interest is the fact that we here find the only sections which we have hitherto worked in which the broad forms (*M. cor-testudinarium*) are in definite excess of the narrow ones (*M. præcursor*). At Dover the narrow forms greatly preponderate, while in Sussex they are more equal in number.

Echinocorys vulgaris var. *gibbus* was always fairly abundant, and quite characteristic of this zone.

Zone of Micraster cor-anguinum.

This, again, is the poorest section of the *M. cor-anguinum*—zone which we have ever worked, for even in the upper part o the zone fossils are by no means common.

Micraster cor-anguinum		upper three-quarters
Micraster cor-anguinum, var. *latior*		
Echinocorys vulgaris (of form peculiar to this zone)		
Echinoconus conicus		
Cidaris perornata		
Micraster præcursor	of form peculiar to this zone	lower quarter
Micraster cor-testudinarium		

Other characteristic fossils are: *Bourgueticrinus ellipticu* *Cidaris sceptrifera*, *C. clavigera*, *Cyphosoma corollare*, *Cyphoson* *königi*.

Micraster cor-anguinum, *M. præcursor*, and *M. cor-testudinariu* entirely conform to the rules which govern the essential features the test in this zone, and in no particular differ from the resu obtained in Kent and Sussex ("Analysis of the Genus *Micraste* *Quart. Journ. Geol. Soc.*, vol. lv, pp. 512, 513). We found examples of *Epiaster gibbus*, a fossil generally regarded as chara-teristic of the zone.

Echinocorys vulgaris is equally reliable as a zonal guide, as i shape-variations are the same as those previously set apart for th zone in the Kent and Sussex paper (*op. cit.*, p. 303).

Echinoconus conicus resembles the form found in this zone Sussex in that it is always restricted to the rounded sha variation—the forma *conica*. In Thanet, and at Gravesend, th dominant form is the forma *pyramidalis*, where both the gia and medium-sized examples are very common. *Echinocor* *globulus* was not seen here, any more than in Sussex.

Bourgueticrinus and *Porosphæra* are characteristic of the zon but Corals are too few and broken to determine accurate *Cidaris sceptrifera* here, as in all other sections, first comes strongly, but the really characteristic species of this zone is *Cida* *perornata*. The same applies to Kent and Sussex.

Mention has been made of an Ammonite of the *leptophyllus*-group, and this is of sufficiently rare occurrence to merit notice. We found one example only on the Kent coast (not mentioned in the Kent and Sussex paper) on the shore at Frenchman's Fall, near St Margaret's Bay. This was clearly derived from the top of the cliff, which is in the *M. cor-anguinum*-zone. At Gravesend Mr. Dibley* has recorded two examples, and from this locality came Sharpe's type. We, therefore, see that Ammonites are very rare at this horizon in the South of England.

No trace of a Belemnite was found in this zone, nor did they occur at the same horizon on the Kent and Sussex coasts. There are, however, certain Belemnites found in the upper part of the *M. cor-anguinum*-zone at Gravesend. While we are alluding to the subject of Belemnites in this zone it may not be out of place to summarise our information on these useful guide-fossils, as found in the South of England. With the exception of Dr. Barrois' "Recherches," Mr. Dibley's paper on the Medway area,† and that by the author on Kent and Sussex, we know of no works which mention the distribution of Belemnites below the zone of *B. mucronata* in England, and we therefore record our experience in the hope that it may induce other field-workers to search this horizon for further examples. It is not a little remarkable that in England we have no record of a Belemnite from the zone of *Act. plenus* upwards, until we reach the *M. cor-anguinum*-zone. In France, however, M. de Grossouvre informs us that *Actinocamax westfalicus* begins in the top of the zone of *M. cor-testudinarium*.

At Northfleet, *Act. westfalicus*, *Act. granulatus* (*A. merceyi*), and *Act. verus* are all associated, and there is no evidence to show that *Act. verus* occurs at a higher level than the other forms. *Act. toucasi* has not been found here, and indeed the only example which we have seen has been obtained by Dr. Blackmore, well up in the *Marsupites*-zone at Salisbury. Too few examples are known to enable us to say whether *Act. toucasi* is a flattened variation of *Act. westfalicus* or a definite species.

The genetic relations between *Act. plenus* and *Act. westfalicus*, are fairly obvious, and the passage from *Act. westfalicus* to *Act. granulatus*, and from *Act. granulatus* to *Act. quadratus* are even more evident and easy. It is clear that we have in the Belemnites almost as perfect an example of evolution as that exemplified in *Micraster*; and were the former more abundant in the lower zones, we believe that they would be of paramount value as zonal guide-fossils. Even with our comparatively limited material it is possible to say, with something akin to certainty, whether *Act. granulatus* or *Act. verus* come from the *M. cor-anguinum*- or *Marsupites*-zones. Those who desire to familiarise themselves

* G. E. Dibley, *Proc. Geol. Assoc.*, vol. xvi, part 9 (Aug. 1900), p. 489.
† G. E. Dibley, *op. cit.*, p. 484.

with these forms should consult the works of Schlüter,* Stolley,† Janet,‡ and de Grossouvre.§ The last named observer has clearly brought out the evidence of the increase in depth of the alveolar cavity, as we ascend the zones, and our own investigations entirely corroborate his views.

While it is easy to group the larger forms so that we have a complete and unbroken transition from *Act. westfalicus*, with its notably shallow alveolar cavity, to the deeply-alveolated *Act. quadratus*, it is by no means so simple to define the point of contact between *Act. westfalicus* and *Act. verus*. Whether *Act. verus* comes off direct from *Act. westfalicus*, or along another line of descent direct from *Act. plenus*, it is impossible to say, for our material is not enough to form a satisfactory conclusion. The only Belemnite which shows any contact between *Act. westfalicus* and *Act. verus* was found by Mr. Griffith in the *M. cor-anguinum*-chalk of Hampshire, but this we prefer to regard as a young *Act. westfalicus*.

It is of interest to note that all examples of *Act. westfalicus* or *Act. granulatus* from the *M. cor-anguinum*-zone of England, which we have seen, are completely devoid of surface granulation, and M. de Grossouvre states that the same feature is the rule in France. In the *Marsupites*-zone, on the other hand, and to a greater extent in the base of the *Act. quadratus*-zone, the granulation on *Act. granulatus* is increasingly developed; so that we can point to progressive granulation, as well as progressive deepening of the alveolar cavity, as an evolutionary feature. *Act. toucasi* is also devoid of granulation. We are free to admit that we find examples of *Act. granulatus* in the *Marsupites*-zone, and in the base of the *Act. quadratus*-zone, as well as of *Act. quadratus* in its own zone, which are devoid of granulation; but the broad fact remains that the bulk of the examples are strongly granulated on the surface.

Against the supposition that *Act. verus* is derived from *Act. westfalicus* we have the undoubted fact that *Act. verus* of the *M. cor-anguinum*-zone is frequently ornamented with surface wrinklings|| (not granulations); and it is curious to note that the percentage of examples of *Act. verus* from the *M. cor-anguinum*-zone with surface wrinkling is almost as large as that on the typical *Act. verus* of the *Marsupites*-zone, though certainly those in the higher zone have it more commonly and to a greater degree.

To summarise the *Act. westfalicus* group in this zone we would say that we can divide it into three stages.

(i.) The feebly alveolated form, sometimes, from lack of

* Schlüter, "Palæntographica," Bd. xxiv, 1876, pp. 183-204.

† E. Stolley, "Archiv für Anthropologie und Geologie Schleswig-Holstein" Bd. I, Heft 2, 1897.

‡ C. Janet, *Bull. Soc. Géol. de France*, 3e série, tome xix, p. 716, June, 1891.

§ A. de Grossouvre, *Bull. Soc. Géol. de France*, 3e série, tome xxvii, p. 129, 1899.

|| For this ornamentation, see Schlüter, *op. cit.*, Taf. lii, Fig. 15.

preservation of the alveolar walls, almost truncated like *Act. plenus*. The appearance is indicated in Schlüter's Taf. liii, fig. 17, 18. The section of the alveolar end of these forms is often cordate and notched, as in *Act. plenus*.

(ii.) A slightly more alveolated form, shading off into the depth of cavity, suggestive of *Act. granulatus*. In this form, and in No. 1, we often see a raised ring at the bottom of the alveolar cavity, embracing the apex of the depression. This is again reminiscent of *Act. plenus*.

(iii.) The moderately alveolated form, which we cannot distinguish from the typical *A. granulatus* of the *Marsupites*-zone, save for the fact that it never has surface granulations.

It is a curious fact that in *Act. westfalicus* and *Act. granulatus* the upper edges of the alveolar walls have often perished. This is especially the case with *Act. westfalicus*, and gives an exaggerated idea of shallowness, even to truncation, of the alveolar end. We fully allow for this fact in estimating our degrees of shallowness of the alveolar cavity.

We draw attention to the fact that *Act. granulatus* of the *Marsupites*-zone and base of the *Act. quadratus*-zone has never the quadrate section of the alveolar cavity which is characteristic of the true *Act. quadratus*.

In the same way we can divide the examples of *Act. verus* into stages. Speaking broadly, all examples derived from the *M. cor-anguinum*-zone are larger, more inflated, and with more abruptly truncated alveolar ends than the typical form of the *Marsupites*-zone; and here again we have the most perfect transition in shape-variations from the large, inflated, and abruptly-truncated forms of the *M. cor-anguinum*-zone to the smaller, tapering, and pyramidal-ended forms of the *Marsupites*-zone. They may be grouped as follows, as regards the alveolar ends:

(i.) The form with flatly-truncated end, like *Act. plenus*, even to the cordate and notched surface. The degree of truncation is illustrated by Schlüter's Taf. lii, figs. 10, 12, and may even exceed this.

(ii.) The less abruptly truncated, and still slightly pyramidal end, which could never be taken for anything else but that of *Act. verus*.

(iii.) The strongly pyramidal end, which cannot be separated from the typical *Act. verus* of the *Marsupites*-zone.

It is only right to mention that we may be able to match any one of these variations of *Act. verus* with similar examples from the *Marsupites*-zone. This is only what we should expect, for we know that features such as these are never abruptly limited by zonal boundaries, but that zonal shape-variations invariably interlock. Still, in our opinion, the general facies of *Act. verus* in the *M. cor-anguinum*-zone differs from that in the *Marsupites*-zone in the way indicated, and is valuable as affording an inde horizon which is useful in the field.

We are in Dorset once more face to face with the ever-pre difficulty about the name-fossil for the *Micraster cor-anguin* zone, and of a method for determining its actual junction with zone of *M. cor-testudinarium*. The *Micraster cor-anguinum-* in Dorset resembles that in Sussex in passing insensibly into zone below. We have no definite lithological guide to assis for the yellow nodular bands, so characteristic of the *M. cor-t dinarium*-zone, pass up in a feebler manner into the zone ab In Kent, however, the line of demarcation is as definite as sible. We mentioned in the paper on *Micraster* (*op. cit.*, p. 514) this urchin in the lower ¼ or ⅓ of the *M. cor-anguinum*-zone sho a far greater affinity with the *M. præcursor*-group of the *M. testudinarium*-zone than with *M. cor-anguinum* auctorum. Sin conditions to those in Sussex obtain here, and indeed, we only tell whether we are in the zone of *M. cor-testudinariun M. cor-anguinum* by an examination of the essential feature the test of *Micraster*. Personally, we are quite content to let t features alone be our guide. It will be found that *Echino vulgaris* var. *gibbus* is much more abrupt than *Micraster* in its t sition from the true gibbous type of the *M. cor-testudinarium-* to the dome-shaped or ovate variations of the *M. cor-anguinum-z* So soon as we find *M. præcursor*, of the group-form character of the base of the *M. cor-anguinum*-zone, we at once notice *Echinocorys* has ceased to be gibbous, and becomes dome ovate. These two factors are absolutely constant in our experie and form a good argument for putting this doubtful area into *M. cor-anguinum*-zone. *Micraster* and *Echinocorys* are the only fossils which are always found in this doubtful area, for *Echinoc conicus* is too rare to take into account, and *Inoceramus invol* is equally unreliable. Both *Echinocorys vulgaris* and *Micr præcursor* are equally important as zonal guides, and as one in favour of the upper zone, and the other of the lower, t evidence is equally balanced. It would be unwise to ma new zone, or sub-zone, of this doubtful area. As we l shown before, no better name-fossil than *M. cor-anguinum* been indicated for this zone, and until we have worked whole of the English Chalk we are content to call it b usual name, and to include in it the barren and debatable l portion.

Zone of Marsupites testudinarius.

When favourably exposed this zone here yields a fairly fauna, and what is of more importance, a fauna which cl coincides with that of the same zone on the coasts of Kent Sussex, and in inland sections in the south of England. have so recently made the first attempt to systematise the f of this interesting zone that we offer no excuse for contrasting the three coast-sections which we have now critically examined. The broad division into *Uintacrinus*-band below, and *Marsupites*-band above, holds good here. We therefore append the tabular summaries, showing the broad zoological divisions of this zone, which we have published for the coasts of Kent and Sussex.

KENT.

a. *Marsupites testudinarius* *Actinocamax granulatus* (*A. merceyi*) *Echinocorys vulgaris* var. *pyramidatus* *Bourgueticrinus* (a special form) *Terebratulina rowei*	Band of *Marsupites testudinarius*, 48 ft. exposed.	Zone of *Marsupites testudinarius* 116 ft.
.... the "Bedwell-line."		
b. Band of *Echinocorys vulgaris* var. *pyramidatus*.		
c. *Uintacrinus* *Actinocamax verus* *Ammonites leptophyllus* *Echinocorys vulgaris* var. *pyramidatus* *Bourgueticrinus* (a special form) *Terebratulina rowei* d. Band of *Echinoconus conicus*	Band of *Uintacrinus*, total thickness, 68 ft.	
vvvvvvvvvvvvvvvvvvvvvvvv "Barrois' sponge bed" the base-line of the zone.		

SUSSEX.

a. *Marsupites testudinarius* *Actinocamax granulatus* *Ammonites leptophyllus* *Echinoconus conicus* *Echinocorys vulgaris* var. *pyramidatus* *Terebratulina rowei* *Bourgueticrinus* (a special form)	*Marsupites*-band, maximum thickness exposed, 58 ft.	Zone of *Marsupites testudinarius*, 86 ft. 9 in.
b. *Uintacrinus* *Echinocorys vulgaris* var. *pyramidatus* *Bourgueticrinus* (the same special form) *Terebratulina rowei*	*Uintacrinus*-band, maximum measurement yet obtained, 28 ft. 9 in.	(To this may be added about 20 ft. for the area between the *Marsupites*-band and the lowest occurrence of *Cardiaster pillula*.)

DORSET

a. *Marsupites testudinarius* *Echinocorys vulgaris* var. *pyramidatus* *Echinoconus conicus* *Bourgueticrinus* (a special form) *Terebratulina rowei*	*Marsupites*-band, 30 ft., in horizontal chalk at White Nothe.	Zone of *Marsupites testudinarius* 111 ft, at White Noth (To this ma be added abo 15 ft. for the ar between th *Marsupites*-ban and the lowe occurrence *Cardiaster pi lul.*)
b. *Uintacrinus* *Echinocorys vulgaris* var. *pyramidatus* *Echinoconus conicus* *Bourgueticrinus* (a special form) *Terebratulina rowei*	*Uintacrinus*-band, 81 ft., in horizontal chalk at White Nothe.	

The fossils, which are constant and common to all three counties, are, therefore :

Marsupites testudinarius,
Uintacrinus,
Echinocorys vulgaris var. *pyramidatus*,
Echinoconus conicus,
Bourgueticrinus ellipticus (a special form),
Terebratulina rowei.

It will be seen that the Cephalopoda are the only guide-fossi which are inconstant in their distribution.

	Kent.	*Sussex.*	*Dorset.*
Ammonites leptophyllus	*Uintacrinus*-band	*Marsupites*-band	Absent in bot bands.
Actinocamax granulatus (*A. merceyi*)	*Marsupites*-band	*Marsupites*-band (upper 20 ft.)	Absent in bot bands.
Actinocamax verus	*Uintacrinus*-band	*Uintacrinus*-band (3 examples only)	Absent in bot bands.

Act. granulatus (*A. merceyi*) was found here at the junction the *Marsupites*- and *Act. quadratus*-zones, and as it was associat with *Cardiaster pillula*, we have included it in the higher zone.

In Dorset and Sussex *Echinocorys vulgaris* var. *pyramida* and *Echinoconus conicus* are found uniformly throughout the zc and there is no evidence of an *Echinocorys*- and *Echinoco* band as in Thanet. *Echinoconus conicus*, as in Sussex, is al of the forma *conica*, and is a comparatively rare fossil, whe in Thanet, all the shape-variations are recorded, and commoner variations are found in abundance.

Micraster cor-anguinum and its var. *latior* was found her was not abundant. No example of the var. *rostratus* was *Zeuglopleurus rowei* was absent as in Sussex, but *Cyphosoma* was collected in all three sections.

istic as in other sections of the zone, but is also rather irregular in its occurrence, having a tendency to run in bands. A rather pointed dome-shaped variety is occasionally seen, and we also obtained the small pyramidal form at the base of the zone, which we mentioned on p. 342 of the paper on Kent and Sussex. Like *Cardiaster pillula* this urchin became rarer as we neared the top of the zone. The passage between *Echinocorys vulgaris* var. *gibbus* and *Echinocorys vulgaris* var. *pyramidatus* was beautifully shown in several sections, and the transition always began to take place below the first occurrence of *Cardiaster pillula*.

Contrary to our usual experience, *Micraster cor-anguinum* was found well up in this zone. We obtained six examples, all badly shattered. We only found it at the extreme base of the zone in Sussex, where it was rare; in the Salisbury area Dr. Blackmore has never seen it; and in Hampshire Mr. Griffith also considers it very rare.

Bourgueticrinus, of the form peculiar to the zone, occurred abundantly (Kent and Sussex, *op. cit.*, p. 344, Pl. VIII, Fig. 10–11a); *Salenia granulosa* and *Cyphosoma corollare* were also present.

Of the more characteristic Brachiopoda, *Crania egnabergensis* var. *striata*, *Rhynchonella limbata*, and *Terebratulina rowei*, should be mentioned. *Crania egnabergensis* var. *striata* is on the whole larger than in the zone below, but it never reaches the size or abundance of *Crania egnabergensis* var. *costata* in the *Belemnitella mucronata*-zone. We have never seen *Crania egnabergensis* var. *costata* in the *Actinocamax quadratus*-zone. *Rhynchonella limbata* is more abundant than in the three zones immediately below, but never so common as in the *Belemnitella mucronata*-zone; moreover, it is flatter, and with a more plicate margin than in the *Belemnitella mucronata*-zone. *Terebratulina rowei* was represented by four examples at the extreme base of this zone, which conform to the characters assigned by Dr. Kitchin to examples from this horizon (Kent and Sussex, *op. cit.*, p. 357).

The Cephalopoda were represented by *Act. quadratus* and *Act. granulatus* (*A. merceyi*) and no Ammonites or Aptychi were found. We have alluded to a well-marked band of *Act. quadratus* at West Bottom, which yielded us fifteen examples. Two others were found, one on a fallen block east of Barber's Rock, and the other at the upper limit of the zone in Arish Mell. The last occurrence must be a rare one, and is notable for the exaggerated granulation on the surface. *Act. granulatus* (*A. merceyi*) was limited to three examples, and these all occurred at the extreme base of the zone, associated with *Cardiaster pillula*. It will be remembered that we have but 170 ft. of this zone exposed in Sussex and that there we have no record of an example of *Act. quadratus* capable of exact determination. *Act. granulatus*, on the other hand, was fairly common at the base of the zone, and extended, with increasing rarity, for 150 ft. from the lower zonal limit. *Belemnitella lanceolata* was not found in this zone in either Dorset or Sussex. We have previously made the statement that this fossil occurs in the lower two-thirds of the zone at Salisbury, and at the top of the zone in Hampshire (Kent and Sussex, *op. cit.*, p. 346). While we are dealing with Cephalopods, it may be of interest to repeat that no Ammonites were found in this zone in Dorset and that the whole coast yielded but two examples—*Ammonites cunningtoni* in the *R. cuvieri*-zone, and a specimen of the *Ammonites leptophyllus*-group at the top of the *M. cor-anguinum*-zone. By way of comparison we mention the fact that in Sussex *A. leptophyllus* is common at the base of the zone, and that we have recorded one example as high as 150 ft. from the junction with the *Marsupites*-zone.

Corals were fairly abundant, but were invariably broken and impossible to develop. *Cœlosmilia laxa* and *Parasmilia fittoni* were apparently the dominant forms, as in Sussex.

Serpula ilium, of the peculiar large form noted on p. 344 of the Kent and Sussex paper, was abundant in the lower part of the zone, and *S. turbinella* quite common. The same distribution obtained in Sussex.

Ostrea, on the whole, was poorly represented, and *O. lateralis* is much less common than in Sussex, or in the inland sections. The var. *striata* was apparently absent.

The remarks made about *Porosphæra* on the Sussex coast hold good here. Not only is *P. woodwardi* abundant and of large size, but it is more pointed than in the zones below, and the grooving more marked. We regard these characters as of zonal significance.

This is clearly a favourable opportunity for reviewing the question of the name-fossil for this zone. As far as this coast is concerned, it is abundantly evident that the scheme which we advanced in the Kent and Sussex paper (*op. cit.*, p. 345), would more suitably meet the case.

Act. quadratus—in upper part	Zone of
Act. granulatus—(*A. merceyi*) in lower part	*Cardiaster pillula.*

In the case of Dorset, *Act. quadratus* is practically limited to a narrow band above the middle of the zone, and *Act. granulatus* to its extreme base. We had no idea that we should find any Belemnites at all on this coast, for neither Dr. Barrois nor Mr. Strahan succeeded in obtaining them. How rare they are may be gathered from the fact that we found under twenty examples in all. Still, we know that *Act. quadratus* is a common fossil in its zone in Continental sections and in certain English localities as well, and, in our opinion, it would be unwise to finally depose the name-fossil until we have examined every English section in this zone. Nothing is more mischievous than to found zonal appellations on data obtained from a restricted area. For this reason we have provisionally retained *Act. quadratus* as the name-fossil in this paper, setting forth, however, how inappropriate it is in the present instance. We again draw attention to the fact that it was not found in Sussex, even at a height of 170 ft. from the base of the zone. From what we have already written it is evident that, save in the zone of *B. mucronata*, Belemnites are very uncertain in their occurrence.

If we exclude *Act. quadratus* as the name-fossil, we are reduced to *Echinocorys vulgaris* var. *gibbus* and *Cardiaster pillula*. The disadvantage of the former is that *Echinocorys vulgaris* var. *gibbus* is also the dominant shape-variation in the zones of *H. planus* and *M. cor-testudinarium*. This would necessitate a re-naming of the var. *gibbus* of the *Act. quadratus*-zone, though, as we have shown in the Kent and Sussex paper (*op. cit.*, p. 342), we can readily distinguish the two forms. Both *Echinocorys vulgaris* var. *gibbus* and *Cardiaster pillula* are beset with the objection that they occur in bands, and that wide intervals occur in which neither of them is found. They are both notably rarer, in our experience, in the upper part of the zone. The large barren areas in this zone are indeed our chief difficulty, and we know of no fossil which completely fills the place of an ideal zonal guide.

Zone of Belemnitella mucronata.

Whatever difficulties we may have in finding a really reliable and restricted name-fossil for other zones, there can be no doubt about the suitability of the title of the zone under discussion. We have found *B. mucronata* from base to top of the zone, as exposed in Dorset, and that in a profusion which is completely satisfying to the believer in zonal geology. The whole fauna of this zone is remarkably rich, and associated with the name-fossil are a number of other forms, which would be equally diagnostic, were the characteristic Belemnite absent. We know of no zone which can boast of a fauna at once so rich and so restricted to its own horizon.

In giving a tabular summary of guide-fossils to this zone we wish it to be understood that they apply to the Dorset section alone. As we add other sections of the *B. mucronata*-zone to our list we shall make the summary applicable to all exposures of this zone in England.

The chief difficulty in considering the fauna of this zone in Dorset, lies in the fact that the fossils are so imperfect and difficult to clean. Even in the horizontal chalk at Ballard Head and Studland Bay, the fossils are often as hard to develop as those derived from the *Terebratulina gracilis*-zone at Dover. We also labour under the disadvantage that our list is confessedly sketchy and incomplete, for we were only able to devote five days to collecting from this section. However, imperfect though it may be, it contains nearly all the fossils which we recognise as characteristic in other sections in the south of England, and for that reason we do not hesitate to make deductions from it.

Tabular summary of guide-fossils of the zone of *Belemnitella mucronata*:

Belemnitella mucronata.
Belemnitella lanceolata.
Aptychus rugosus.
Echinocorys vulgaris (two special forms).
Cardiaster ananchytis.
Cidaris serrata.
Cidaris subvesiculosa.
Cidaris pleracantha.
Magas pumilus.
Crania egnabergensis var. *costata.*
Kingena lima (a special shape-variation).
Rhynchonella limbata (a special shape-variation).
Ostrea vesicularis (a special shape-variation).
Porina filograna.
Serpula difformis (?)
Serpula gordialis (?)

Other characteristic fossils are *Cidaris hirudo*, *Cidaris* n. sp., *Micraster cor-anguinum*, *Bourgueticrinus*, *Calliderma latum*, *Oreaster bulbiferus*, *Lima granosa*, *Pecten cretosus*, *Janira quinque-costatus*, *Cœlosmilia laxa*, *Stephanophyllia michelini*, *Pollicipes fallax*, *Scalpellum fossula*, *S. maximum*, *Pyrgoma cretacea*, *Eschara danaë*, *Vincularia santonensis*, *Serpula turbinella*, *S. ampullacea*, *Porosphæra*, and sponges.

Belemnitella mucronata and *B. lanceolata* are found throughout the zone, though the former is notably the dominant form. Both these Belemnites were found in the highest part of the zone exposed in Studland Bay, above the yellow band, though they became rarer as we ascended the zone. We are under the impression that *B. lanceolata* was rarer in the upper one-third of the zone than in the lower two-thirds. We cannot examine the actual base of the zone at Ballard Head, as the sea-weed prevents an inspection of the cliff, and we are unable, therefore, to say if *B. mucronata* there extends to the extreme base. We found one large example 39 ft. south of the fault, and on the north side they were abundant. At Arish Mell, however, we found several examples near the lower limit of the zone. We obtained none in the top of the *Act. quadratus* zone. It is of interest to note that *B. lanceolata* here occurs in moderate frequency in association with the commoner *B. mucronata*. In this respect it coincides with our experience at Norwich and Trimingham. At Salisbury as we have mentioned before, it is found only in the lower two-thirds of the *Act. quadratus*-zone, while in Hampshire it occurs at the top of that zone, and is occasionally associated with *B. mucronata*. In the latter locality it is a rare fossil. Were our knowledge of *B. lanceolata* confined to Dorset and Norfolk we might have reason to regard it as a local, or even a sexual, variation; but its absence from the *B. mucronata*-chalk of Hampshire and Wiltshire clearly disposes of the supposition of mere sexual variation, and its presence in the *Act. quadratus*-zone of Wiltshire, unaccompanied by *B. mucronata*, is equally conclusive on this point. In these Belemnites, as in all the other large groups, we can trace a blending of forms, for while we can readily pick out examples which are completely typical of *B. lanceolata*, there are other passage-forms which insensibly link *B. mucronata* and *B. lanceolata* together. On the whole, therefore, we incline to the belief that *B. lanceolata* should rank as a definite species. Belemnites are frequently bored by *Cliona* and *Talpina*, and are often encrusted with Bryozoa, Corals, *Ostrea*, *Plicatula*, and Foraminifera. *B. mucronata* does not run to a large size in Dorset, the largest examples being 105 mm. long (about $4\frac{1}{4}$ in.). The bulk of them rarely measured more than 80 mm.

Aptychus rugosus was obtained, and we record it as a guide-fossil, as we have never found it outside this zone. We saw no trace of an Ammonite.

The Echinoderma are here an interesting group, and are abundantly represented. *Echinocorys vulgaris* is very rarely found in a perfect state at Ballard or Studland, but we obtained the small pointed shape-variation (much resembling in contour the forma *pyramidalis* of *Echinoconus conicus*), and this we regard as characteristic of the lower one-third of the zone. We found it at the base of the zone at Arish Mell, and two examples were secured in the fissure-cave at the base of the fault. A band of this urchin was discovered north and south of the southernmost pinnacle.

As far as we could ascertain from shattered examples, the large dome-shaped variety of *Echinocorys* is represented by a flat form, and a rather tall and pointed form. The latter is not so acuminate as the magnificent specimens from Norwich, nor does it reach so great a size.

There is also a dwarfed sub-pyramidal form, measuring only about 28 mm. long, 23 mm. broad, 20 mm. high, which recurs sporadically throughout the lower two-thirds of the zone. The test is very thin, and, as it was generally found in section, it much resembled *Cardiaster pillula*. We believe that this is the first record of this new and interesting variety. Neither *C. pillula* nor *Echinoconus conicus* were found in this zone.

Cardiaster ananchytis here reaches a large size, and is not uncommon. We only found it in a fragmentary condition.

Spines of Cidarites are common, and of these the dominant form is *Cidaris serrata*, Desor. We note a peculiarity in the or mentation of these spines. In several instances we found that t dentations were triple, consisting of a central large denticle, w a smaller one on each side of it. We mention the other Cidari spines according to the frequency of their occurrence—*Cida hirudo*, *C. subvesiculosa*, *C. pleracantha*, and *Cidaris* n. sp.

Cidaris hirudo presents no zonal peculiarity, and *C. subv culosa* has none of the curious characters which we found in th from the Trimingham chalk. *C. pleracantha* was represented four examples, all found in the upper one-third of the zone. I Blackmore and Mr. Griffith do not know it in the Wiltshire a Hampshire chalk, and the only English records which we c find are by Wright, who quotes it from the Grey Chalk of Suss and Dorking. D'Orbigny, on the other hand, refers it to t Upper White Chalk of Sussex, so this would probably locate it the zones of *Act. quadratus* and *Marsupites testudinarius* ne Brighton. It occurs, however, at Meudon; so that the record i the *B. mucronata*-zone is substantiated. It is remarkable that England no authentic examples have been found to bridge ov the wide gap between the Grey Chalk and the *B. mucronata*-zo No test of this species has ever been discovered.

The spines of *Cidaris* n. sp., to which we have alluded, a small and thin, of much the same diameter throughout t length, with feeble longitudinal ridges devoid of denticles, a with faint longitudinal markings between the ridges. Dr. Bla more discovered this form at Salisbury some time ago, and have since found it at Ballard Head and Trimingham. It is ve rare, and has not been found associated with any part of the te We mention this form in order that other collectors may sea for it. We record *Cyphosoma radiatum* and *C. corollare*, b found no examples of *Salenia*. Dr. Blackmore states that *Sale geometrica* is a rare fossil in the *B. mucronata*-chalk of Salisbu and Mr. Griffith does not obtain it in Hampshire.

A notable occurrence is that of *Micraster cor-anguinum*, rare that Dr. Blackmore and Mr. Griffith have never seen it Wiltshire and Hampshire, and Mr. Westlake possesses but c young and damaged example. Those which we found here w badly shattered, but they indicated a shape-variation allied to tha *Micraster brongniarti*, Hébert, from the Meudon chalk, in t the anteal sulcus and ambital notch were very deep, and t peristome near the margin. Our examples were more depres than the Meudon form, but that may have been due to press *M. cor-anguinum* is found at Norwich, Weybourne, and Trimi ham. We saw no example of *Epiaster gibbus*, which occurs b at Norwich and Trimingham.

Bourgueticrinus would here again appear to have a charac istic head and columnar. The head is small and nipple-shap much resembling that figured as typical of the *Marsupites*-z

(Kent and Sussex, *op. cit.*, Pl. VIII, figs. 6, 6A), but still distinct from it. The columnars are slender and contracted in the centre, like those from the *Act. quadratus*-zone (*ibid.*, Pl. VIII, fig. 11), but with the articular surfaces rather more excavated. Dr. Blackmore first pointed out this excavation to us in the Salisbury forms. We have not collected sufficient examples to warrant us in giving an illustration of them.

Asteroidea are represented by numerous detached ossicles, the most notable of which are the large rounded ossicles of *Oreaster bulbiferus*, and the still larger flat ones of *Calliderma latum*. In this section the rounded ossicles of *O. bulbiferus* are smooth, and not pitted. *Pentacrinus* was not found. In the chalk of Norwich, Sheringham and Trimingham *P. agassizi* and *P. bronni* are very common.

The Brachiopoda constitute a prolific and most useful group. Of these the most important is undoubtedly *Magas pumilus*, which is here both abundant and of large size. It is commonly of a pink or purple colour. We found it near the sluice at Arish Mell, but failed to obtain it near the Ballard fault. It only comes in strongly when we near the strong yellow band, and both below and above that level it is very common. We traced it to the highest beds of the zone, as exposed in Studland Bay. In the pits in the vertical chalk of the Chalk Ridge we always found it, though there, curiously enough, *Belemnitella mucronata* itself was conspicuous by its absence in almost every pit. In the horizontal chalk of the Wool area it occurred in profusion. It is a curious fact that at Salisbury, according to Dr. Blackmore, it is not only very rare (only three examples) but very small (4 mm. in diameter). In Hampshire, Mr. Griffith says that it is confined to the upper part of the zone only, and this agrees with our experience, as we only found it in any quantity in the upper half of the zone. It is abundant at Trimingham, rarer at Norwich, and we record one small example from Weybourne (Norfolk Coast). We have never seen it in the top of the *Act. quadratus*-zone, and regard it as rigidly confined to the *B. mucronata*-chalk.

Rhynchonella limbata we have traced upwards from the top of the *M. cor-testudinarium*-zone, every section in each zone yielding a few examples. But in the *B. mucronata*-zone it comes in suddenly, and is abundant throughout the zone. We regard a small inflated form as quite characteristic of this zone. This form is figured by Samuel Woodward in "An Outline of the Geology of Norfolk" (Tab. vi, Fig 11) as *Terebratulina lentiformis*, Woodward, and by Davidson in the British Fossil Brachiopoda (Pal. Soc., Pl. XII, Fig. 4, 5.) as *R. limbata* var. *lentiformis*, Woodward. Both of these figures admirably illustrate the form in question. The variations found in the lower zones are less inflated, and with a more plicate margin. The lentiform variation is very common at Norwich, along the Norfolk coast, and at Trimingham. The large forms figured by Davidson are, in our experience, only found a Norwich. Dr. Barrois, on page 103 of his "Recherches," record both *R. limbata* and *R. subplicata*, Mantell, from Ballard Head From Mantell's figure ("Fossils S. Downs," Pl. XXVI, Figs 5, 6, 11) there can be no doubt that the latter is only *R. limbata* but not the var. *lentiformis*.

We found no example of *Rhynchonella reedensis*, nor does Dr Blackmore record it from Salisbury; but Mr. Griffith, however states that it occurs in this zone in Hampshire. We obtained two examples at Norwich, two at Weybourne, but none at Trimingham. Mr. Brydone also failed to find it in the last locality.*

All examples of *Rhynchonella plicatilis* were shattered at Ballard and Studland, and even at Wool we only obtained damaged specimens. There seems to be nothing characteristic in the shape, judging from our imperfect material. We found no example of the var *octoplicata*; nor have we seen any from other sections which in any way approach the large dimensions of those which are so common at Norwich.

Terebratula carnea, of the Meudon form, is common here, but i invariably shattered. We collected it from base to top of th zone. The form which we found here is of medium size, with curved and pointed beak, and small foramen, differing considerably from the spurious forms of the zones below. At Trimingham but more especially at Norwich, it runs to a great size, and is often strongly inflated. In examining 300 examples from Norwich we were impressed with the variation in size of the foramen, some specimens having a minute opening, and others one of considerable size. We regard the Meudon form as the true *T. carnea*, and as strongly characteristic of the zone.

It is a notable fact that in this zone *Terebratula carnea* entirely replaces *T. semiglobosa*, which from the base of the White Chalk upwards has been the dominant form, save in the zone of *Holaster planus*. We found no examples of *T. semiglobosa* here, and our experience coincides with that of Dr. Blackmore at Salisbury. At Norwich we only saw three examples, and at Trimingham none. Mr. Brydone also does not record it from the last locality. We have only found *Terebratula obesa* in the Norwich and Trimingham Chalk.

Kingena lima here assumes a shape-variation which is fully diagnostic of the zone. It is large and pentagonal. These characters begin to appear in the *Act. quadratus*-zone, and are notably seen in Dr. Blackmore's series from the Salisbury Chalk but the full development of the pentagonal shape is only met with in this zone. The difference between the smaller and rounder form, so common in the *Marsupites*-zone, is most marked This shape-variation is well figured as *Terebratula pentangulata*

* R. M. Brydone, "The Stratigraphy and Fauna of the Trimingham Chalk London: Dulau and Co., August, 1900.

Phillips, by S. Woodward, in the "Geology of Norfolk" (Tab. vi, fig. 10), and by Davidson ("Brit. Foss. Brach.," Pal. Soc., pt. 11, No. 1, 1852, pl. iv. fig. 20).

There is no fossil more characteristic of this zone, wherever it may be exposed in the south of England, than *Crania egnabergensis* var. *costata*. We here found it in profusion throughout the zone, from the extreme base at Arish Mell to the highest beds at Studland. We found no trace of it in the top of the *A. quadratus*-zone, so it would appear to be restricted to its own particular horizon. Davidson appears to have entirely failed to grasp the horizonal significance of this Brachiopod.

Lamellibranchiata are here richly represented. The oysters found are *Ostrea vesicularis*, *O. wegmanniana*, *O. lateralis*, *O. hippopodium*, and a small form rather suggestive of *O. alæformis*, Woodward, but clearly not that species. *O. vesicularis* is the only species requiring mention. This shape-variation would appear to be characteristic of the zone, for we have found it at Norwich and on the Norfolk Coast. It differs widely from the huge forms so common at Norwich and Trimingham.

Hitherto, we have only met with the true *O. alæformis*, Woodward, at Norwich. In the paper on the Chalk zones of Kent and Sussex (*op. cit.*, p. 300) we implied that it occurs in the *Marsupites*-zone. We desire to correct that impression, and to state that the form there mentioned is only suggestive of *O. alæformis*.

Janira quinque-costatus is abundant, but never perfect. *Spondylus dutempleanus* reaches a large size, and its attached valve is greatly developed—even more so than in the *A. quadratus*-zone. *Lima granosa* is common and richly ornamented, but it never reaches the large size which we find at Norwich and Trimingham. Dr. Blackmore records it from Salisbury.

We did not find *Spondylus spinosus*, nor does Dr. Blackmore at Salisbury, though Mr. Griffith records it from Hampshire. It is found at Norwich, where it is of small size; but Mr. Brydone did not obtain it at Trimingham, and we were equally unsuccessful.

Pecten cretosus is here always fragmentary, and of moderate size. We found no examples of *P. concentricus* or *P. pulchellus*, which are common at Norwich and Trimingham. At Salisbury Dr. Blackmore states that *P. cretosus* is replaced by *P. concentricus*.

The Bryozoa are abundant, and if the chalk were more tractable would yield a rich harvest. The form which is peculiarly characteristic is *Porina filograna*. This is abundant throughout the zone, and is equally common at Norwich, the Norfolk coast, and at Trimingham. It is also found at Salisbury. *Eschara danae* and *Vincularia santonensis* are also well represented. We purposely do not mention adnate forms, or small free forms, as we only record those which readily catch the eye. We found several fine branches of a very massive *Heteropora*, which we have never seen before. At present we have been unable to identify it. The characteristic *Cribrilina* of the *A. quadratus*-zone was not found in this *B. mucronata*-chalk, so that its restricted range makes it all the more useful as a zonal guide.

The Cirripides are neither abundant nor of large size, and are represented by *Scalpellum maximum*, *S. fossula*, and *Pollicipes fallax*. We regard the latter as suggestive of the zone. The Cirripides are small compared with those at Norwich, where they seem to reach their maximum development in point of size. We have here an interesting record of *Pyrgoma cretacea*, H. Woodward, from the Whiteway Farm Pit on the Chalk Ridge. The only other known example was collected by Mr. Bayfield at Norwich, and is now in the British Museum (Nat. Hist.). We were fortunate enough to find an almost perfect example at Norwich, which we submitted to Dr. Henry Woodward, who referred it to this species.

The Corals are nearly always fragmentary, and chiefly consist of *Cœlosmilia laxa*, and an indeterminable form of *Parasmilia*. We did not find *Onchotrochus serpentinus*, which Dr. Blackmore obtains at Salisbury, and Mr. Brydone at Trimingham. One of our most interesting records is that of *Stephanophyllia michelini* (four examples) of rather small size, all of which were obtained at about the level of the strong yellow band.

The Serpulæ are abundant, and two forms at least appear to be characteristic of the zone. *Serpula macropus* and *S. fluctuata* present no peculiarities. *Serpula turbinella* is very common, and the same applies to *S. ilium*, which has here ceased to exhibit the large size which we consider to be characteristic of the *A. quadratus*-zone. *Serpula ampullacea* is found in two forms, the one of ordinary size, and the other a very large and massive form, which we have never met with outside this zone. *Serpula plana* is fairly abundant, but not so common as at Norwich. The two Serpulæ which we regard as characteristic are a smooth, curved form and a hexagonal form.

The smooth, curved form appears to be common in all sections of the *B. mucronata*-chalk, and is found at Norwich and Trimingham. Mr. Brydone submitted his Trimingham forms to Prof. Deecke, who referred them to *S. gordialis*. The other form is invariably hexagonal in Dorset, and it also occurs at Salisbury. We have never seen it outside this zone, and are unable to refer it to any figure. Mr. Brydone considers it to be *S. difformis*, Dixon, but it differs greatly from the Trimingham examples, which are always pentagonal and bluntly-angular. We are not satisfied with the determination of these two forms, but feel that they are of such zonal value that they must be recorded.

We did not find *Serpula plana*, *S. gordialis* var. *serpentina*, or *S. granulata*. The chance of obtaining adnate forms is poor, as the echinoderms to which they are attached are invariably fragmentary.

The *Porosphæra* group is decidedly interesting, especially in the case of *P. globularis*. Here it reaches a large size, and has a peculiar shape-variation, being in the form of a flat cushion. This is here quite common, and is practically diagnostic of the zone. We have, however, one example from the zones of *Marsupites* and *Act. quadratus*, which foreshadows this zonal variation. We record the same form from Norwich, where it is even larger, and have seen one example from Sheringham and Trimingham. *P. woodwardi* is less pointed than in the *A. quadratus*-zone, though that character is not by any means lost. *P. pileolus* is here comparatively rare and of small size.

We have made no attempt to collect the sponges of this zone, as they were too shattered to be capable of being cleaned. *Ventriculites radiatus*, *V. cribrosus*, and *Plocoscyphia convoluta* were noted, and we especially desire to record an abundance of *Leptophragma murchisoni* and a species of *Aphrocallistes*, as we found them both in the same zone in the Isle of Wight. We regard these species as characteristic of the zone. *Ventriculites radiatus* never rivalled the profusion or large size in which it occurs at Sheringham and Runton, on the Norfolk coast.

CONCLUSION.

We have shown that the whole of this coast is fraught with difficulties, and we are but too well aware that our reading of the zonal features may be, for this reason, by no means final. Still, these very difficulties bring with them a corresponding measure of fascination and interest. But, in spite of altered and barren rocks, we have been able to fix, with varying degrees of accuracy, the limits of nearly every zone, and with the solitary exception of the belt of chalk which we assign to the *Actinocamax quadratus*-zone at Ballard Head, we have been able to record a characteristic fauna for every horizon. Where zoological data are not present we have frankly admitted the fact, preferring to leave a gap in the symmetry of our record to endeavouring to make our survey theoretically ideal and complete. We give such measurements as we have obtained, even though they militate against our own convictions as to their suitability. Those who follow us will realise the difficulties, and appreciate our inability to produce an ideal result.

We have no desire to exaggerate these difficulties, but we would set forth our conviction that they afford an indisputable proof of the validity of zonal geology. If we can win characteristic faunas and zonal junctions from rocks such as these, we need never despair of obtaining them elsewhere. After this, zonal geology needs no apologist. We take no personal credit for tl work, for, after all, it only implies ordinary careful collecting.

We have endeavoured to show that the dominant zonal guid fossils, which have served us so well in Kent and Sussex, persi with equal reliability on the Dorset coast. To this end we ha drawn comparisons between the three counties in the zoologic summary. An attempt has been made to demonstrate the equal instructive and interesting variation in distribution of oth associated guide-fossils, and we claim that this record of variati in distribution forms one of the most useful features of the pap Further, in pursuance of the line of argument, advanced in tl first paper, that many guide-fossils afford by their shape-variatio not only an important index to horizon, but an evidence definite and progressive evolution, we have put on record ma facts bearing on this point which have not hitherto be published.

Owing to the slight difference in level between high and lc tide on this coast, it is impossible to get a good view of the clif for merely working along the face of the section gives one a d torted idea. The only way is to view these from a boat, n once, but repeatedly. By this means we obtain a comprehensi idea of the dip of the beds, and of the relative positions of tl rocks which lie between the Chalk and the Portland Stor Without it we have no sense of proportion or men perspective.

This same inability to get far enough from the cliff-fa renders the photographer's task a peculiarly thankless one. take a really satisfying series of views it would be necessary live on this coast for several months, and we are, therefore, the more grateful to Professor Armstrong for obtaining su admirable results. He has been at much pains to achieve th and has had to make several visits to Dorset for this spec purpose, more than one of which have been rendered futile hostile atmospheric conditions. We should have liked to g double the number of plates, but the cost of production h tempered our enthusiasm. Those who desire to obtain a rea graphic idea of the coast between White Nothe and Bat's He and of that between Ballard Head and Studland Bay, sho refer to Englefield's "Isle of Wight," in which are includ Webster's spirited and accurate drawings of the Dorset Co (Plates 26, 27, 28, and 46).

We had the great advantage of the company of Profes Lapworth and Mr. Teall on one of our excursions; we were al to obtain their criticism on the whole coast, from White No to Arish Mell. It now only remains to thank those who ha so freely placed their knowledge and services at our disposal.

Professor Lapworth generously offered to have the maps a sections drawn in his office under his direction, and we take t

opportunity of tendering our grateful thanks for so great a kindness.

We have received invaluable assistance in geological matters from Dr. Barrois, M. de Grossouvre, Mr. Jukes-Browne, Dr. Henry Woodward, Dr. A. Smith Woodward, Dr. F. A. Bather, Mr. G. C. Crick, Dr. F. L. Kitchin, Mr. Henry Woods, Dr. Blackmore, Mr. C. Griffith, Mr. R. M. Brydone, Mr. E. Westlake, Mr. G. E. Dibley, and Major-Gen. Cockburn, and to each one we desire to express our gratitude for help so willingly given. To Mr. H. A. Allen and Dr. Cullis we are indebted for much sage counsel and unwearying patience in getting this somewhat lengthy paper through the press. To Mr. Charles Davies Sherborn, above all, we would record our lasting obligation for not only his share of the field-work, but for the admirable maps and sections which he has prepared for this paper, without which it would be pointless and unintelligible.

SHEETS OF 6-INCH MAPS EMPLOYED.

Wool area (horizontal Chalk)	Sheet XLIX.
Osmington to Lulworth	„ LIV.
Lulworth to Worbarrow	„ LV (N.W.).
Worbarrow to Kimeridge	„ LV (N.E.).
Chalk Ridge	„ LVI.
Studland to Durlstone	„ LVII

LIST OF THE PLATES.

NOTES TO LIST OF FOSSILS.

It is felt that, while it is essential to record the zonal range of any given fossil, it is equally important to record the comparative frequency of its occurrence. The following abbreviations have been employed:

C. common; R.C. rather common; R. rare; R.R. rather rare.

No Bryozoa are included in the list, as time does not permit one to work out the numerous specimens in the collection, so as to show their zonal distribution. This will be done in a subsequent communication.

The free and adnate Ceriopora, and other allied forms, are not listed, partly for the same reason, and partly because there is no reliable work of reference to consult.

The Serpulæ are not fully recorded, as many common forms have not been identified.

The Foraminifera and Ostracoda are not listed, as they are so rare that no advantage can be obtained by recording them in this paper.

Asteroidea, which are generally badly preserved in coast-sections, are, save in the zone of *Belemnitella mucronata*, represented in Dorset only by detached ossicles. It has been found to be impossible to determine the species, so we have made no attempt to give any index of their zonal distribution.

The lack of reliability of fish-teeth as zonal guides has never been more strongly evidenced than on this coast, where we record but three species.

The whole list of fossils is notably meagre, and a comparison with that appended to the paper on Kent and Sussex renders the fact more prominent. Many fossils, which are more or less characteristic of certain zones, are unrecorded. Barren though these rocks are in Dorset, it is only fair to state that our collecting has been much less extended than in the case of Kent and Sussex, and that further search would probably fill up many noteworthy gaps.

The poor list of Gasteropoda and Cephalopoda (with the exception of the Belemnites in the *B. mucronata*-zone) is especially noteworthy.

LIST OF FOSSILS FROM THE DORSET COAST.

C. common; R.C. rather common; R. rare; R.R. rather rare.

	Zone of *Rhynchonella cuvieri.*	Zone of *Terebratulina gracilis.*	Zone of *Holaster planus.*	Zone of *Micraster cor-testudinarium.*	Zone of *Micraster cor-anguinum.*	Zone of *Marsupites testudinarius.*	Zone of *Actinocamax quadratus.*	Zone of *Belemnitella mucronata.*
Cliona cretacea, Portl.	R.	R.	C.	R.C.	C.	C.	C.	C.
Stichophyma tumidum, Hinde	...	...	...	...	R.	...	...	...
Doryderma ramosum, Mant.	...	...	...	...	...	...	C.	...
Heterostinia obliqua, Benett	...	...	R.	R.	R.	R.	C.	...
Siphonia königi, Mant.	...	...	R.	R.	R.C.	R.	R.C.	R.
Plinthosella compacta, Hinde	...	...	...	...	...	...	R.R.	...
Craticularia fittoni, Mant.	R.	R C.	...	...	...	...	...	...
Guettardia stellata, Mich.	...	R.C.	R.R.	...	R.	...	R.R.	R.
Coscinopora infundibuliformis, Goldf.	...	...	R.	...	R.C.	R.	R.C.	R.C.
Leptophragma murchisoni, Goldf.	...	...	...	...	...	...	...	C.
Ventriculites convolutus, Hinde	...	...	...	...	R.	...	...	...
Ventriculites cribrosus, Phill.	...	R.C.	R.C.	...	R.	...	...	R.C.
Ventriculites decurrens, T. Smith	...	...	R.C.	...	R.R.	R.	R.R.	R.C.
Ventriculites impressus, T. Smith	...	...	R.C.	...	...	...	...	...
Ventriculites mammillaris, T. Smith	...	R.	R.R.	...	...	...	...	...
Ventriculites radiatus, Mant.	...	R.	R.C.	R.R.	R.C.	R.C.	R.C.	C.
Plocoscyphia convoluta T. Smith	R.C.	C.	R.C.	R.C.	C.	C.	C.	C.
Pharetrospongia strahani, Sollas	...	...	...	R.C.	R.C.	R.C.	R.C.	R.
Aphrocallistes sp.	...	...	...	...	...	...	...	C.
Porosphæra globularis Phill.	R.C.	C.	C.	C	C.	C.	C.	C.

LIST OF FOSSILS FROM THE DORSET COAST.—*Continued.*

	Zone of *Rhynchonella cuvieri.*	Zone of *Terebratulina gracilis.*	Zone of *Holaster planus.*	Zone of *Micraster cor-testudinarium.*	Zone of *Micraster cor-anguinum.*	Zone of *Marsupites testudinarius.*	Zone of *Actinocamax quadratus.*	Zone of *Belemnitella mucronata.*
Porosphæra pileolus, Lam.	...	...	R.	...	R.C.	R.C.	C.	R.C.
Porosphæra woodwardi, Carter	...	...	...	...	R.R.	R C	C.	R.C.
Parasmilia sp.	...	...	R.	...	...	...	...	R.C.
Parasmilia centralis, Mant....	...	...	...	...	R.R	R.R.	R.C.	...
Parasmilia fittoni, Edw. and Haime	...	...	...	...	...	...	R.C.	...
Cœlosmilia laxa, Edw. and Haime...	...	...	...	...	...	...	R.C.	C.
Caryophyllia cylindracea, Reuss	...	...	...	...	...	R.	...	...
Axogaster cretacea, Lonsd.	...	...	R.	...	R.	...	...	R.C.
Stephanophyllia michelini, Lonsd.	...	...	...	...	...	...	...	R.R.
Bourgueticrinus	R.	R.	R.R.	R.	C.	C.	C.	R.C.
Pentacrinus agassizi, Hag.	...	R.	C.	...	...	R.	...	...
Marsupites testudinarius, Mill.	...	...	...	...	...	C.	...	...
Uintacrinus	...	...	...	...	...	C.	...	...
Asteroidea	R.R.	R.	R.C.	R.R.	C.	C.	C.	C.
Oreaster bulbiformis, Forbes	...	...	...	...	...	...	...	C.
Oreaster pistilliferus, Forbes	...	...	R.	...	...	...	...	...
Calliderma latum, Forbes	...	...	...	...	...	...	...	R.C.
Ophiura	...	R.	...	...	...	...	...	...
Cidaris sceptrifera, Mant.	...	...	R	R.R.	C.	R.R.	...	...
Cidaris clavigera, König	...	R.	R.C.	R.C.	R.R.	R.	...	...
Cidaris perornata, Forbes	...	...	...	...	R.C.	...	...	...
Cidaris hirudo, Sorig.	R.C.	R.C.	R.	...	R.	R C.	R C.	R.C.

LIST OF FOSSILS FROM THE DORSET COAST.

C. common ; R.C. rather common ; R. rare ; R.R. rather rare.

	Zone of *Rhynchonella cuvieri.*	Zone of *Terebratulina gracilis.*	Zone of *Holaster planus.*	Zone of *Micraster cor-testudinarium.*	Zone of *Micraster cor-anguinum.*	Zone of *Marsupites testudinarius.*	Zone of *Actinocamax quadratus.*	Zone of *Belemnitella mucronata.*
Cliona cretacea, Portl.	R.	R.	C.	R.C.	C.	C.	C.	C.
Stichophyma tumidum, Hinde	...	...	...	...	R.	...	...	...
Doryderma ramosum, Mant.	...	...	...	...	...	...	C.	...
Heterostinia obliqua, Benett	...	...	R.	R.	R.	R.	C.	...
Siphonia königi, Mant.	...	...	R.	R.	R.C.	R.	R.C.	R.
Plinthosella compacta, Hinde	...	...	...	...	...	...	R.R.	...
Craticularia fittoni, Mant.	R.	R.C.	...	...	...	...	...	...
Guettardia stellata, Mich.	...	R.C.	R.R.	...	R.	...	R.R.	R.
Coscinopora infundibuliformis, Goldf.	...	...	R.	...	R.C.	R.	R.C.	R.C.
Leptophragma murchisoni, Goldf.	...	...	...	...	...	...	...	C.
Ventriculites convolutus, Hinde	...	...	...	...	R.	...	...	...
Ventriculites cribrosus, Phill.	...	R.C.	R.C.	...	R.	...	...	R.C.
Ventriculites decurrens, T. Smith	...	...	R.C.	...	R.R.	R.	R.R.	R.C.
Ventriculites impressus, T. Smith	...	...	R.C.	...	...	...	...	...
Ventriculites mammillaris, T. Smith	...	R.	R.R.	...	...	...	...	...
Ventriculites radiatus, Mant.	...	R.	R.C.	R.R.	R.C.	R.C.	R.C.	C.
Plocoscyphia convoluta T. Smith	R.C.	C.	R.C.	R.C.	C.	C.	C.	C.
Pharetrospongia strahani, Sollas	...	...	...	R.C.	R.C.	R.C.	R.C.	R.
Aphrocallistes sp.	...	...	...	...	...	...	...	C.
Porosphaera globularis Phill.	R.C.	C.	C.	C	C.	C.	C.	C.

LIST OF FOSSILS FROM THE DORSET COAST—*Continued.*

	Zone of *Rhynchonella cuvieri.*	Zone of *Terebratulina gracilis.*	Zone of *Holaster planus.*	Zone of *Micraster cor-testudinarium.*	Zone of *Micraster cor-anguinum.*	Zone of *Marsupites testudinarius.*	Zone of *Actinocamax quadratus.*	Zone of *Belemnitella mucronata.*
Serpula plana, S. Woodw.	...	...	R C.	R.C.	R.	R.	R.	R.C.
Serpula plexus, Sby.	...	...	...	...	R.R.	...	...	...
Serpula planorbis, Gein.	...	...	...	...	...	R.	...	...
Serpula fluctuata, Sby.	...	...	R.	R.C.	R.	R.	R.	R.C.
Serpula difformis ?, Dixon *	...	...	...	...	...	...	...	C.
Serpula sp.	R.R.	...	...	...	...	...	...	...
Serpula sp.	...	R.	...	...	...	...	...	...
Crania parisiensis, Defr.	...	...	...	R.	R.	...	...	...
Crania egnabergensis, Retz. var. *striata*	...	...	R.R.	...	...	...	R.C	...
Crania egnabergensis var. *costata*, Sby.	...	...	...	...	...	...	...	C.
Thecidea wetherelli, Morris	...	...	...	...	R.	R.	R.	...
Kingena lima, Defr.	...	...	...	...	...	...	...	C
Terebratulina striata, Dav.	...	R.	R.	...	R.R.	R.	R.R.	R.R.
Terebratulina gracilis, Schloth.	R.	C.	R.C.	...	...	...	...	...
Terebratulina rowei, Kitchin	...	...	...	...	...	C.	R.	...
Terebratula semiglobosa, Sby.	R.	R.C.	C.	R.C.	R.C.	...	R.	...
Terebratula carnea, Sby.	R.	...	C.	...	...	...	...	C.
Rhynchonella limbata, Schloth.	...	...	...	...	...	...	R R.	C.
Rhynchonella reedensis, Eth.	R.	R.	R.R.	R.	R.C.	R.R.	R.C.	...
Rhynchonella cuvieri, d'Orb.	C.	R.C.	R.R.	...	...	...	...	...
Rhynchonella plicatilis, Sby.	...	...	R.C.	...	R.R.	R.R.	R.C.	R.C.

* See p. 66.

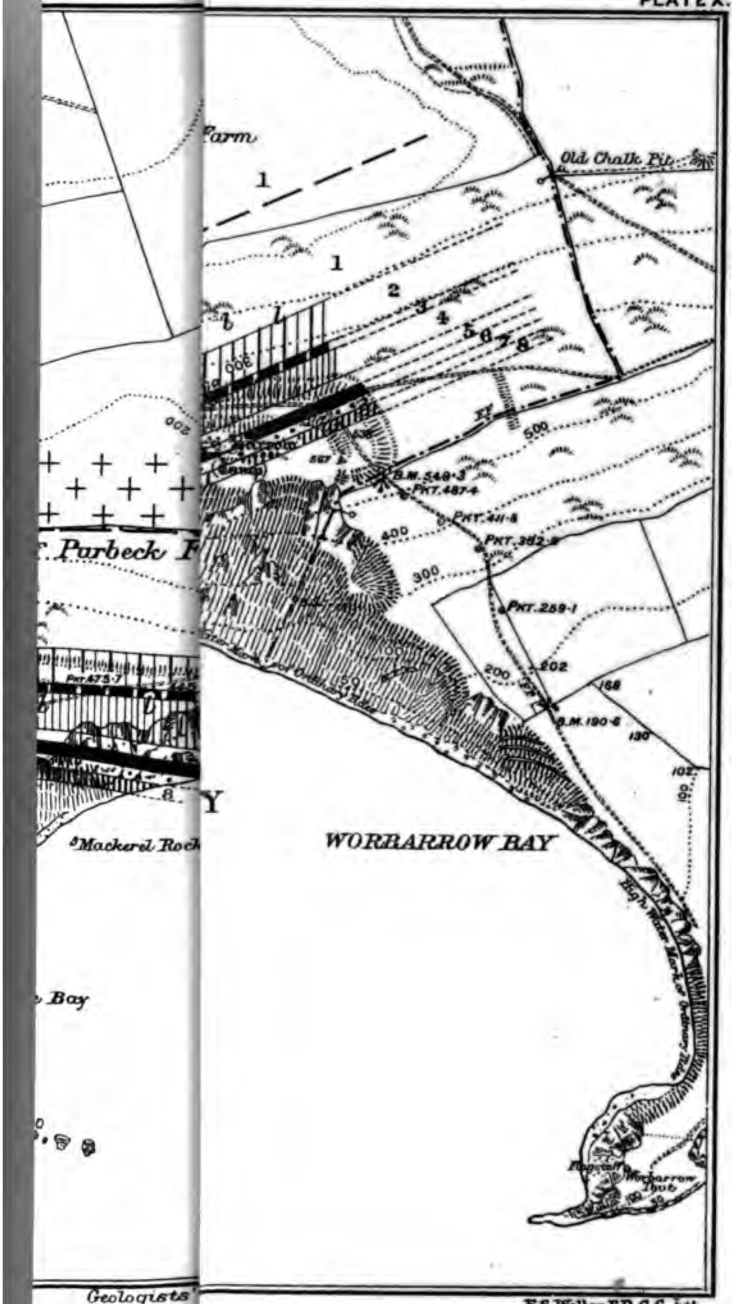
Rhynchonella plicatilis var. *octoplicata*, Sby.	...	...	R.C.	...	...	R.	...	...
Magas pumilus, Sby.	...	...	...	...	...	...	...	C.
Pecten cretosus, Defr.	...	R.	...	...	R.	R.	R.C.	C.
Janira quinque-costatus, Sby.	...	...	R.	...	R.	R.R.	C.	C.
Spondylus spinosus, Sby.	...	R.C.	R.C.	R.C.	R.C.	R.C.	R.C	...
Spondylus dutempleanus, d'Orb.	...	...	...	...	R.	R.	R.C.	R.C.
Spondylus latus, Sby.	...	R.	R.	R.	R.C.	R.C.	R.C.	R.C.
Lima granosa, Goldf.	...	...	...	...	...	R.	...	C.
Ostrea vesicularis, Lam.	...	...	R.	R.	R.R	R.C.	R.C.	C.
Ostrea hippopodium, Nils.	R.	R.	R.C.	R.C.	R.C.	R.	R.R.	R.R.
Ostr a semiplana, Sby.	...	...	R.	...	...	...	...	R.
Ostrea normaniana, d'Orb.	R.	R	R.	...	R.	...	R.R.	...
Ostrea wegmanniana, d'Orb.	...	...	...	...	...	...	...	R.
Ostrea curvirostris, Nils.	R.	...	...	...	...	...	...	...
Ostrea lateralis, Nils.	...	...	...	...	...	...	...	R.C.
Plicatula sigillina, Woodw.	...	...	R.C.	R.C.	C.	R R.	R C.	C.
Plicatula barroisi, Peron	...	...	R.R.	...	...	...	...	...
Inoceramus brongniarti, Sby.	...	R.	R.	...	...	...	...	...
Inoceramus cuvieri, Sby.	...	C.	C.	C	C.	C.	C.	C.
Inoceramus labiatus, Schloth.	C.	C.	R.	...	...	...	...	...
Ino. eramus sp.	...	...	...	...	...	...	R.	...
Inoceramus sp.	...	...	...	...	...	...	...	R.
Inoceramus sp. *	...	...	R R.	...	...	...	...	...
Teredo amphisbæna, Goldf.	...	...	R.	...	...	...	...	...
Pleurotomaria perspectiva, Mant.	...	...	R.R.	...	...	...	...	...
Turbo gemminatus, Sby.	...	R.	R.	...	...	...	...	...
Ammonites cunningtoni, Sharpe	R.	...	...	...	...	...	...	...
Ammonites leptophyllus, Sharpe (group)	...	...	...	...	R.	...	...	...
Aptychus rugosus, Sharpe	...	...	...	...	...	...	...	R.R.
Belemnitella mucronata, Schloth.	...	...	...	...	...	...	...	C

* Henry Woods, "The Mollusca of the Chalk Rock," Pt. ii, *Quart. Journ. Geol. Soc.*, vol. liii, 1897, Pl. xxvii, Figs. 14—17.

LIST OF FOSSILS FROM THE DORSET COAST.—*Continued.*

	Zone of *Rhynchonella cuvieri.*	Zone of *Terebratulina gracilis.*	Zone of *Holaster planus.*	Zone of *Micraster cor-testudinarium.*	Zone of *Micraster cor-anguinum.*	Zone of *Marsupites testudinarius.*	Zone of *Actinocamax quadratus.*	Zone of *Belemnitella mucronata.*
Belemnitella lanceolata, Schloth.	...	...	...	...	...	...	...	R.C.
Actinocamax quadratus, Blainv.	...	...	...	...	...	...	R.R.	...
Actinocamax granulatus, Blainv. (=*A. merceyi*, Mayer-Eymer)	...	...	...	...	...	...	R.	...
Scalpellum maximum, Sby.	..	...	...	...	...	...	...	R R.
Scalpellum fossula, Darw.	...	...	...	...	...	...	...	R.R.
Pollicipes fallax, Darw.	...	...	...	...	...	...	...	R.R.
Pyrgoma cretacea, H. Woodw.	...	...	...	...	...	...	...	R.
Lamna appendiculata, Ag.	...	...	...	...	...	R.	...	R.
Corax falcatus, Ag.	...	...	...	...	...	...	...	R.
Oxyrhina mantelli, Ag.	...	...	...	...	...	...	R.	...

PLATE X.



Geologists'

F.S. Waller, F.R.G.S. lith.

ORDINARY MEETING.

FRIDAY, NOVEMBER 2ND, 1900.

ITAKER, B.A., F.R.S., President, in the Chair.

wing were elected members of the Association: Miss rker, Miss E. D. Davies, Hartley T. Ferrar, Prof. T. .A., D.Sc., Miss M. Healey, Thomas E. Lones, M.A., , Humphrey M. Morgans, Miss Agnes Robertson, C. C. Spicer, B.A., F.G.S., Mrs. J. J. H. Teall, H. H. .., F.G.S.

ting then resolved into a Conversazione, and the list of the exhibitors and their exhibits:

ENT: Specimens of a fossiliferous band in the Wool-ds lately found at Croydon.

M.R.C.S.: A remarkable series of Concretionary om the Magnesian Limestone of Durham.

SETT: Artificially produced spherulitic and perlitic es obtained by chemical methods.

NE BIRLEY: A large collection of Tertiary Echinoidea Maltese Islands.

BROWN: Chalk Fossils from Coulsdon and Ruxley.

SHINGTON BULLEN, B.A., F.G.S.: Specimens and llustrating the exhibitor's recent Victoria Institute n "Eolithic Implements." A series of Eolithic, hic and Neolithic implements including typical ns of hammers, parallel-flaked rimers, straight-edged und-edged sleekers, Palæolithic saws, hand stick , Neolithic sling-stones, Neolithic hoes, Eolithic neoliths dressed on one edge only, &c. North n spear- and arrow-heads, &c. Polished section of rites from Shoreham, Kent; and Carborundum from Falls City.

CHAPMAN, F.R.M.S.: Photo-micrograph lantern-f foraminiferal limestones.

IARA SWAMY, B.Sc., F.L.S., F.G.S.: Photograph of e, Cockington, N. Devon, and a specimen of *Palæo-lichotomus*? From the Upper Lias of Kettering.

EY, F.G.S.: Vertebrata from the Chalk of Cuxton, , Gravesend and Strood.

LIOTT: A series of stone war axes from Peru.

CH, F.G.S.: Insects in amber.

NCIS: A specimen of *Ophioderma milleri* from the Staithes, Yorkshire, and a collection of Liassic ites and Belemnites from Yorkshire.

HAM: A fine specimen of a Viking sword dredged e Thames at Lambeth.

W. F. GWINNELL, B.Sc., F.G.S.: Miocene fossils from the Faluns of Touraine; specimens from the Temple of Jupiter Serapis and from the surrounding neighbourhood; photographs illustrating geological structures, &c.

MARTIN A. C. HINTON: Original drawings made by J. de C. Sowerby and Rev. G. E. Smith to illustrate Dr. Fitton's memoir "On the Strata between the Chalk and the Oxford Oolite" (*Trans. Geol. Soc.*, ser. 2, vol. iv).

MARTIN A. C. HINTON and A. S. KENNARD: Small Vertebrata from the Pleistocene deposits of Grays.

MISS M. S. JOHNSTON: Photographs of geological interest taken during the recent excursion of the Geological Congress to Central France.

A. S. KENNARD: Eolithic and Palæolithic Implements from West Kent.

D. A. LOUIS, M.I.M.E.: Specimens from the gypsum quarries at Noisy-le-Sec and Romainville near Paris. Photographs of Park Quarry, Romainville, showing 200 ft. vertical exposure, kindly sent by Mons. Léon Janet, of Paris. Table showing the horizon and succession of the gypsum beds. Specimens of metallic chromium and metallic manganese obtained by the action of metallic aluminium on the oxides of the two metals.

F. P. MENNELL: A series of minerals from Australia.

HORACE W. MONCKTON, F.L.S., F.G.S.: Geological photographs.

E. T. NEWTON, F.R.S. F.G.S.: Palæolithic Implements from Chard, and Graptolites from Barf, Keswick.

J. PARKINSON, F.G.S.: Rock specimens from the Raniganj and Kurharbaree coalfields of Bengal.

HENRY PRESTON, F.G.S.: Flints from Manton Moor, North Lincolnshire.

A. E. SALTER, B.Sc., F.G.S.: Bunter pebbles with flat faces from the "Drift." Igneous rocks (erratic) from Hertfordshire and Essex. Worked (?) flints from N.W. Essex, &c. Southern erratics from N. Essex, &c. Coal containing a tooth coated with iron pyrites from Newcastle.

JOHN SHEER: Flint implement from the valley of the Axe, Somerset.

J. E. STEAD: Photo-micrographs illustrating the structure of alloys.

W. P. D. STEBBING, F.G.S.: Fossils collected during the year at excursions, including some from supposed "Lenham" Beds at Netley Heath, Surrey; and the Association's album of Geological Photographs.

J. J. H. TEALL, M.A., F.R.S., P.G.S.: Geological photographs by F. H. Teall; and a faulted slate from the Lake District.

ROBERT TERVET: Specimens of Ozokerite and natural Hydrocarbons from the Mines of Broxburn, Linlithgowshire, sent by Mr. D. R. Stewart.

DR. R. H. TRAQUAIR, F.R.S., F.G.S.: Figured specimens of *Palæospondylus gunni*, Traq., from the Middle Devonian of Achanarras, Caithness.

S. HAZZLEDINE WARREN, F.G.S.: Palæolithic implements from the Chalk Downs of the Isle of Wight.

MISS E. WHITLEY, B.Sc.: Rock specimens (phonolites, trachytes, basalts, &c.) collected during the recent excursion of the Geological Congress to Central France.

F. R. B. WILLIAMS: Carapace and three bones of *Pleurosternum bullocki* from the Purbeck Beds of Swanage, and photographs of geological phenomena in the neighbourhood of Swanage.

A. SMITH WOODWARD, LL.D., F.L.S., F.G.S.: Devonian Fish-remains from Queensland (collected by George Sweet, F.G.S.). Devonian Fish-remains from East Greenland (collected during the Swedish Expedition of 1899).

HORACE B. WOODWARD, F.R.S., F.G.S.: Wooden Pebbles from Oxwich Bay, Gower.

A. C. YOUNG, F.C.S.: Specimens and micro-sections of rocks collected during the recent excursion of the Geologists' Association to the Lake District.

ORDINARY MEETING.

FRIDAY, DECEMBER 7TH, 1900.

W. WHITAKER, B.A., F.R.S., President, in the Chair.

The following were elected members of the Association: Herbert L. Bowman, S. E. Brown, B.A., Eggliston Burrows, M.D., L.R.C.P., F. L. Daniels, H. N. Dickson, B.Sc., F.R.S.E., Charles P. Gibbons, A.M.I.C.E., E. J. Holden, Percy F. Kendall, W. J. Le Lacheur, B.A., Joseph Lomas, William Simpson, Albert du B. Wilson.

A paper was read by Dr. A. W. Rowe, F.G.S., on "The Zones of the White Chalk of the English Coast. Part II, Dorsetshire." The paper was illustrated by lantern slides taken by Prof. H. E. Armstrong, Ph.D., F.R.S., and by sections drawn by C. Davies Sherborn, F.G.S., F.Z.S.

Mr. Ogilvie exhibited some water colour drawings of the Dorsetshire coast.

ELVE YEARS OF LONDON GEOLOGY.

(GENERAL, RECENT, AND DRIFT.)

By W. WHITAKER, B.A., F.R.S.

(Presidential Address delivered February 8th, 1901.)

1. INTRODUCTORY.

:HOUGH we are a wandering body and the distance of our meetings from London as a rule varies directly as their , yet our head-quarters are in London, and most of our st excursions are to places in the neighbourhood. I feel :d, therefore, in limiting my remarks to home affairs, and I it may not be unprofitable for us to see what has been done years for the geology of our great city and its surroundings. ook up this task with a comparatively light heart, though ng that very much had been done in the matter since the hen it seemed possible that I might have done with it for but as my work went on my feelings changed. Perhaps :ver fully realises the literature of a subject until one tries it all together, Industry is thought to be a virtue in those ursue it; but it often gives a deal of trouble to other people. great is the multitude of the papers in this case that in to stem the inflowing tide I have had to put a stratigraphic o my remarks and to stop at the base of the Drift, besides other steps to avoid over-burdening you.

may be suggested that a definition of what is meant by)ON should be given. This I decline to do. LONDON indefinite term, and, as a Londoner born and bred, I will t bounds to it.

ndon in the strictly correct sense implies the City only; th such a paltry area no self-respecting geologist would be t.

sing higher in the scale, to Municipal London, the much tract governed by the County Council, we have something But equally with the City, and with most other areas of rt, its boundaries are more or less absurd, and it does not include all that well-regulated minds, such as ours, under- by LONDON.

ıother term has been invented of late years, "Greater ›n." So long as this is used in an indefinite way, I like it; ıen it is sought to define it as a "district known at the al Register Office," with an area of 701 square miles and ing certain parishes which have some relation in distance to

ORDINARY MEETING.

FRIDAY, JANUARY 4TH, 1901.

W. WHITAKER, B.A., F.R.S., President, in the Chair.

The following were elected members of the Association: Edwin J. Boyce, Herbert T. Burls, F.G.S., Miss Gertrude L Elles, Edwin H. Fedarb, H. J. Glover, Charles H. Sherring.

Mr. J. E. Piper and Captain A. W. Stiffe were elected Auditors.

A lecture was delivered by Mr. Horace W. Monckton, V.P.G.S., entitled "The Geology of Swanage—Chapman's Pool to Punfield Cove (Kimeridge Clay to Upper Greensand)," and was illustrated by a large number of lantern slides, taken by the lecturer.

Sir Henry Howorth exhibited a photograph of a tree trunk *in situ* in the Lower Coal-Measure Shales of Rochdale.

TWELVE YEARS OF LONDON GEOLOGY.

(GENERAL, RECENT, AND DRIFT.)

By W. WHITAKER, B.A., F.R.S.

(Presidential Address delivered February 8th, 1901.)

1. INTRODUCTORY.

ALTHOUGH we are a wandering body and the distance of our meetings from London as a rule varies directly as their length, yet our head-quarters are in London, and most of our shortest excursions are to places in the neighbourhood. I feel justified, therefore, in limiting my remarks to home affairs, and I think it may not be unprofitable for us to see what has been done of late years for the geology of our great city and its surroundings.

I took up this task with a comparatively light heart, though knowing that very much had been done in the matter since the time when it seemed possible that I might have done with it for ever; but as my work went on my feelings changed. Perhaps one never fully realises the literature of a subject until one tries to get it all together, Industry is thought to be a virtue in those who pursue it; but it often gives a deal of trouble to other people.

So great is the multitude of the papers in this case that in order to stem the inflowing tide I have had to put a stratigraphic limit to my remarks and to stop at the base of the Drift, besides taking other steps to avoid over-burdening you.

It may be suggested that a definition of what is meant by LONDON should be given. This I decline to do. LONDON is an indefinite term, and, as a Londoner born and bred, I will not put bounds to it.

London in the strictly correct sense implies the City only; but with such a paltry area no self-respecting geologist would be content.

Rising higher in the scale, to Municipal London, the much larger tract governed by the County Council, we have something better. But equally with the City, and with most other areas of the sort, its boundaries are more or less absurd, and it does not really include all that well-regulated minds, such as ours, understand by LONDON.

Another term has been invented of late years, "Greater London." So long as this is used in an indefinite way, I like it; but when it is sought to define it as a "district known at the General Register Office," with an area of 701 square miles and including certain parishes which have some relation in distance to

Charing Cross, it ceases to appeal to my feelings. The geologic mind does not care for the General Register Office, its odd square mile, and its parochialism.

There happen to be three other sorts of a greater London; one, the tract covered by the districts of the eight London Water Companies, another, that within the jurisdiction of the Metropolitan Police, and the third, the Postal area. These are all more or less practical: water, police, and post are very good things in their way, but they are not specially scientific, and no one of them has any relation to any other; their boundaries are generally at cross-purposes.

I decline, therefore, to be bound by any hitherto defined London, and if you wish me to state what London I am going to refer to I will coin a fresh one, and answer "Geologic London," or, if you like it, "Greatest London," and I am disposed to extend our view rather eastward and westward, or along the Valley of the Thames, than northward and southward.

In other words, I am going to take my boundary just where I please. Freedom is our greatest blessing, and why should your President be debarred from it? By following this course I can leave out what seems convenient to leave out and can take in what seems fit to take in. There are obvious advantages in this, and amongst them that it enables me to avoid the Bagshot question, the late slumber of which it would be rash to disturb. Another somewhat controversial subject, Dene Holes, which really belongs more to the antiquaries than to the geologists, can also be passed by.

One may be able to treat of the indefinite geologic London; but I do not care to enter into the much more indefinite geologic Time. There are various reasons for the short period to which I have limited myself, the chief of which may be enough. This is that about twelve years ago there appeared a work in which it was attempted to note all that was known of London geology. That such an attempt should fall short of perfect success is only an acknowledgment that we are human; but I believe that the author left comparatively few stones unturned in his search through the literature of the subject and that he faithfully recorded what he himself had seen. I will leave it to others to point out errors in his views; but will note the more important papers that escaped him.

As some day someone may have to pass through the press a second edition of the work in question, I am saving that person some trouble in drawing attention to some of the chief publications that he will have to examine up to now. It is to be hoped that there will be many more then.

In carrying out the task that I have set myself certain classes of literature have had to be neglected for reasons of time and space. These are, firstly, papers of a general kind, with merely incidental reference to the neighbourhood of London; secondly, short notes, of which there are many in several publications; and, thirdly, accounts of excursions, in themselves forming a bewildering mass of literature, to which this Association is the chief contributor, though there are, I am glad to say, other societies that make notable additions.

I trust to be forgiven if shorter notice is sometimes taken of our own papers than of those in other journals, for the former should be in your hands.

I do not propose to adopt a purely chronologic arrangement, as I have lately done for two similar subjects, in one of which the geologic work of ten years in the County of Hertford was described, thus fringing part of our northern border; whilst in the other Surrey was treated in like way, so that our southern border is also partly provided for, much of that county being outside even my London. I propose now to group the various papers stratigraphically, beginning at the top with Recent beds and working downward.

Before, however, starting on the downgrade it will be convenient to notice some works of a general character which do not lend themselves to the purely stratigraphic arrangement; for example, the publications of that body in which I served so long and to which I shall ever be drawn by feelings of scientific brotherhood and of personal attachment, the GEOLOGICAL SURVEY.

When at times I turn off into the realms of criticism let me be forgiven: one cannot ever record facts without commenting on them, or opinions (be they ever so pious) without differing from them.

2. GENERAL.

1889.

Not long after the publication of the detailed Memoir on the Geology of London[1] there appeared a fifth edition of the little Guide to the Geology of London, but as the changes in this are not important, and as a sixth edition is now in the press, there is no need to say more

1891.

The "Handbook of the London Geological Field Class"* (under the guidance of Prof. SEELEY) covers our district and a good deal beyond. It contains notes of many sections in pits and brickyards made by the students, with general remarks by Prof. SEELEY. This is a fit companion to another work of the year, our own "Record of Excursions, made between 1860

* Small 8vo, *London*, pp. xxii, 216. Price 4s.

and 1890,"* in itself a full justification for our existence, s u work as probably no other society in the world could brought out.

1893.

W. J. L. ABBOTT. "A New Reading of the Highgate A way Section."†

The author proposes to abolish the name Bagshot for sands here, and to call them "sands of the London Cla Should this be done, other Bagshot Sand should follow, and shall have a long name instead of a short one. The fossilifer green sand to which he alludes has always been classed with London Clay, in which it forms a local layer; but the sand of higher ground, into which the London Clay passes up (as usu is as good Bagshot as any other.

The general section here (putting together text and figure as follows:—

5. Sand with clay, chert, flints, &c.
4. Sand.
3. Clay.
2. Green fossiliferous sand.
1. Clay with fossils.

1–3 are classed as London Clay by all geologists, as far a know, and 4 as Bagshot Sand.

As regards 5, the author's description is clearly not that ordinary Bagshot Sand, but, as he suggests, that of a Drift, an is shown as cutting across the other beds, down to 2.

Over this in places is "re-deposited London Clay," tho whether this is of glacial origin, as suggested, may be doubt The author alludes to the extent to which material here has b displaced by man, but perhaps does not give this its full credit

1895.

By the publication of Sheet 12 of the Index Map of Geological Survey, on the scale of 4 miles to an inch, the pu were enabled to get a good colour-printed geologic map London and its surroundings, to a goodly distance, for the sr sum of half-a crown. This map takes in the whole of the Valle the Thames from Henley downward, and includes the gre part of the London Basin, and nearly the whole of the We Owing to the smallness of the scale Drift had to be omitt moreover, it has not been mapped over the whole of the area. far as London is concerned, however, this want has been supp by a smaller map published in the Memoir now to be noticed

* 8vo, *London.* Edited by T. V. HOLMES and C. D. SHERBORN.
† *Proc. Geol. Assoc.*, vol. xiii, pt. 4, pp. 84-89.

1897.

H. B. Woodward. "Soils and Sub-soils from a Sanitary Point of View; with especial Reference to London and its Neighbourhood."*

This little memoir should hardly need to be referred to, as all you who are Londoners will know it well; but for the benefit our country-members, and to make this address as complete I can, it must be noticed.

Its object was to help in answering the many enquiries made Jermyn Street "by the public for information regarding sites r houses, and other questions involving the practical application f geological science": but it does more than this, for it shows eologists the practical value of their science, and how this value nay be brought before the outsider, so as to enlist his help in iding us to record facts that might otherwise be lost to science.

The geology of a large district is described from the made round down to the Wealden beds. In the introduction this is etched in stratigraphical order; but in the next chapter (pp. —26) this is done at greater length in lithological order, that is, cording to the character of the beds instead of according to ir age, sandy beds, beds of a mixed kind, and clays being pectively grouped, with chalk as the only limestone, and in the geously-coloured map a like plan is adopted, six colours being uped under "clayey series," three under "gravelly series," and e under "sandy series," leaving severely alone the Alluvium he top and the Chalk at the bottom.

I have long hoped to see some geologic map in which tigraphic and other scientific considerations should be blown he wind and facts only should be shown, and though I have e something of the sort myself, with special reference to water, ve wanted more. Now I have it; and, naturally, want still e.

The long, elaborate Index (10 pages) is a monument to the nuity of the author. It records places shown on the map as as those referred to in the text; it gives their heights above nance Datum; and, by a system of appended letters, it notes r geologic formations.

1898.

J. L. Lobley. "The Geology of Ealing."†

In this compilation, as such a work must be, the author ses the geologic formations under two epochs, that in which massive strata were formed, and that in which the Valley of Thames was excavated and the various superficial formations

* *Mem. Geol. Survey, England and Wales*, pp. vi, 58, folding map. Price 2s. 6d.
† Edith Jackson's *Annals of Ealing*. Lond. pp. 299-340.

were deposited. All are described, the later deposits in some detail, and five pages of bibliography (1813—1897) conclude this elaborate essay, which unfortunately is practically hidden from geologists, from its method of publication.

1889.

3. RECENT.

F. C. J. SPURRELL. "On the Estuary of the Thames and its Alluvium."*

Some reference is naturally made to the gravels of the valley, and we are told that "there are among the lower patches of gravel some in which no extinct remains, nor stone implements have been found which are not clearly remanié," as, for example, a spread on either side the river between London and Gravesend, which is often 20 feet or more above the bordering marsh. The author thinks that this is "the result of the violent breaking up of the neighbouring older gravels by frost and floods"; but he seems to me to be rather straining a point when he divides it from gravel containing Palæolithic implements which sometimes underlies it. How is the division to be made? If it be not made, then the peculiar character assigned to the upper gravel passes away. Moreover, this same gravel is said to "graduate into a lower layer, which spreads across the whole valley . . . at its deepest," and which "presents the usual features of a river-deposit."

A diagram shows the slope of this lowest gravel down the valley, from Richmond to Gravesend, with a difference of from 60 to 70 feet.

Sections in the Alluvium at Tilbury and Crossness are described, and the characters of the peat and of the tidal clay (marsh-clay) are noted at length.

At Crossness the upper layer of peat was strewn over "with abundance of Roman pottery," and various other fragments were found.

"As all the layers of peat . . . were distinctly dry land surfaces, while the layers of clay represent salt-marshes subject to the tide, the alternate layers of alluvial peat and clay represent interrupted subsidence of the land beneath the sea-level."

"From the moment when the gravel was laid on the bed-rocks of the river until now there has been no break in the continuity of the deposits."

A list of the mammalian remains is given, and lists of the plants and shells (from Crossness, Albert Dock, and Tilbury).

* *Proc Geol. Assoc.*, vol. xi, no. 4, pp. 210-230.

This is the most important paper on these latest beds, in our district, that has ever appeared, and we have published it.

1890.

A Report by the County Surveyor, by H. STOCK, on the "silting up" of the River Roding, which it is probably difficult to get, is noticed by the Essex Field Club.* He finds that an artificial narrowing of the channel is reason enough for the frequent floods, and draws attention to the bad condition of the stream as a water-carrier.

G. J. LAWRENCE. "Remarks on the Geological Position of the Skulls dredged from the Thames."†

This follows a paper by DR. GARSON on the Skulls, which were found at Hammersmith, between Mortlake and Kew, in Lion Reach, and at Twickenham. Sections of the river-bed at the first two sets of places are given, and the position of the Skulls noted. They came "from the lowest layer of the river bed, that lying upon the London clay"; but as "implements of stone, bone and bronze have been found in this stratum" it would seem not to be gravel in place, but resorted material, and DR. GARSON's description of the Skulls agrees in a reference to neolithic age at the most.

Mr. B. B. WOODWARD's paper on Pleistocene Mollusca can be more conveniently noticed under Drift, and also MR. ABBOTT's sections in London.

1892.

T. V. HOLMES. "The Geology of the District around Dagenham Breach."‡

This treats of the alluvial flat of the Thames, and of the influence of the river itself in the production of the surrounding scenery, by gradual erosion. My friend was unfortunately troubled by the great thickness of 400 feet, assigned by me to the London Clay at Dagenham Hall in a well-section. We found afterwards that the slip of a contributor in putting Dagenham instead of Dagnam (a very different place) was the cause of this tribulation!

1896.

F. CHAPMAN. "On some Pleistocene Ostracoda from Fulham."§

Clay from near Hurlingham which had yielded shells to MR. WOODWARD (see 1890) was found to contain in addition

* *Essex Naturalist*, vol. iv, pp. 94.
† *Journ. Anthrop. Inst.*, pp. 26, 27.
‡ *Essex Naturalist*, vol. vi, pp. 142-6.
§ *Proc. Geol. Assoc.*, vol. xiv, pt. 7, pp. 299-301.

valves of Ostracoda, and the seed-cases of *Chara*. The former are described.

1897.

T. H. Wilson. "Note on Sections in the Lea Valley at South Tottenham."*

Gives a general section through the Alluvium to the gravel in the new reservoir of the East London Water Company, showing a peaty-bed with shells, of which a list is given, 10 species, all previously recorded in the Lea Valley (see Kennard, under Drift).

Considering the comparitive rarity of sections in these later deposits, and the somewhat limited range of the deposits themselves, we may be satisfied with the work done on them.

4. DRIFT.

1889.

Dr. H. Hicks. "Pre-historic man in Britain."†

In this lecture by our former President, there is, on pp. 149, 150, a short account of various Drift beds in Middlesex, which are more fully treated of in his paper of 1891, so that we may pass them by for a while, merely noting that he takes the Pebble Gravel of the hills to be of early Glacial age, as also the bed "containing large stones at the base of the gravels in the Thames Valley."

J. A. Brown. "Working Sites and Inhabited Land Surfaces of the Palæolithic Period in the Thames Valley."‡

A summary of researches by various authors on the subject, with some additions to his own work on it. He thinks "that the Palæolithic implements of the Valley of the Thames indicate the occupation of the valley by man for an enormous period, and represent a vast epoch of continuous human industry."

Mr. G. F. Lawrence told him that his largest finds at Wandsworth were from a bed of gravel 10 ft. down, and about 60 ft. above O.D., and "that from the comparatively small area of 13 by 83 yards he obtained a large number of Palæolithic implements . . . besides about three thousand flakes."

The highest level at which a Palæolithic flint-tool has been found in N.W. Middlesex is 177 ft. above O.D. at Hillingdon. The author thinks "that man was living in this region" when the boulder clay was "left upon the surface as the ice melted," and that he advanced northward or retreated southward as the ice retreated or advanced.

* *Essex Naturalist*, vol. x, nos. 4-5, pp. 110, 111.
† *Trans. Herts. Nat. Hist. Soc.*, vol. v, pt. v, p. 147.
‡ *Trans. Midx. Nat. Hist. Soc.*, Session 1888-89, pp. 40-73, 5 plates.

The remark that "no ordinary modern inventor can compare in importance with the savage who first made the discovery how to fabricate a flint implement" probably leaves our great inventors some claim to rank as such.

T. V. HOLMES. "On some Recent Subsidences near Slifford."*

I am not going to be drawn by another former President into the Dene Hole question, which this paper leads to; but only to notice the author's view, enforced in later papers, that some of the gravel between Siifford and Grays marks "the former course of an ancient river representing the existing Mardyke." I would rather class all this gravel as belonging to the old Thames, thinking the Mardyke to be a more modern stream, not started perhaps till after the formation of this high terrace. We must remember that underground dissolution of chalk may account for many irregularities of level in overlying gravel.

1890.

SIR J. PRESTWICH. "On the Relation of the Westleton Beds . . . of Suffolk to those of Norfolk, and on their Extension Inland . . . Parts ii. and iii. (The Southern Drift)."†

This paper is almost wholly concerned with districts outside London, but the author traces the pebbly Westleton series to the EppingHills and Buckhurst Hill in Essex; through Middlesex, on the high grounds of Barnet, Totteridge and Mill Hill and South Mimms, into Hertfordshire. He doubts whether the gravels of Highgate and Hampstead belong to this or to the Southern Drift; and refers those of Stanmore and Elstree to "the Brentwood group," of rather older age than the Westleton Beds (pp. 135-137.)

South of the Thames, he does not refer the Shooter's Hill or Swanscombe Hill gravel to this horizon (p. 143).

In section 3 (pl. vii.), the only one that refers to London, the gravel of Norwood is classed as Southern Drift, that of Highgate as doubtfully so, and that of Potter's Bar as Westleton Beds.

For my own part I doubt the safety of some of these divisions and prefer to treat the pebbly series of early Glacial or Preglacial beds as one, except where it can be clearly shown to be divisible, as is often the case with the Southern Drift.

In the second paper a detailed section at Norwood is given and the gravel of Wimbledon Common is also referred to the Southern Drift (pp. 158, 159). The gravels of Highgate and Hampstead are noticed, and the author says, "On the whole these Drift-beds show more analogy with the Southern Drift than

* *Essex Naturalist*, vol. iii, pp. 183-8.
† *Quart. Journ. Geol. Soc.*, vol. xlvi.

with the Westleton Beds. It is posssible, however, that in the case of Hampstead Hill the two may have had the same floor and got intermixed (p. 163)."

On pp. 165, 166 the Stanmore gravel is described, and that of Shooter's Hill is also classed with the Brentwood group.

On p. 171 there seems to me an error, in describing "the narrow valley of Smitham Bottom" as "commencing at Croydon," for it rather ends there, or passes into the broader valley of the Wandle. This valley is instanced as an example of the diversion of drainage, its higher part, near Merstham, having been cut off by the cutting back of the Chalk escarpment, and the drainage of this southern tract having thus been diverted from the Wandle to the Mole (pp. 171, 172).

E. T. NEWTON. "On the Occurrence of Lemmings and other Rodents in the Brick-Earth of the Thames Valley."*

Another old President records jaws and teeth of two species of lemming and of a vole, small mammals "not hitherto known to occur in that district," from Ilford, Crayford, and Erith.

T. V. HOLMES. "On some Sections between West Thurrock and Stifford, on the Grays and Upminster Railway."†

Records cuttings that show inclined junctions of Valley Drift and Chalk, and points out that if it is needful to invoke any glacial action to explain the contorted appearance of the beds, the position of the lumps of chalk in the gravel, and the general confusion at the junction, such action need only be "merely that of ordinary river-ice"; and in a postcript adds that later visits lead him to doubt "the need of any form of glacial action to produce the extremely irregular junction," for which "ordinary pipe-making action seems . . . to be quite competent."

W. H. DALTON. "Note on the Upminster Brickyard."‡

Gives a section showing two loams and two gravels, with a certain amount of irregularity between the upper loam and gravel and the lower set; but ice-action is not called into account for this, the author holding that "we do not need to enter the Arctic Circle to learn how the Thames formed its gravels and loams."

H. W. MONCKTON. "On the Boulder-clay in Essex."§

He concludes that this clay is the product of a sheet of land-

* *Geol. Mag.*, dec. iii, vol. vii, pp. 452-5.
† *Essex Naturalist*, vol. iv, pp. 143-9.
‡ *Ibid.*, vol. iv, pp. 186, 187.
§ *Ibid.*, pp. 199-201.

ice which surmounted the Epping Hills. This gave rise to some controversy in the following year,* which, however, does not bear on my subject.

B. B. Woodward. "On the Pleistocene (Non-Marine) Mollusca of the London District."†

The title of this paper is not fully descriptive of the contents, much of which is concerned with the beds and the sections hereof. In the Notes on the Localities, pp. 338-352 are taken up with Recent and Alluvial, the River Drift then following to p. 378.

As regards the Alluvium, the author says that "in attempting to deduce from the mollusca any conclusions respecting the age of the beds in which they occur, or the nature of the physical conditions under which these were formed, the greatest caution is of course necessary," a remark that might be extended to other cases.

The author thinks that some of the River Drift was deposited in a lake-like expansion, in which case the highest would be the newest, though in an ordinary river it would be the reverse. As he allows that both series may be present in a valley, we may expect curious results.

When the Crayford beds are described as 100 feet thick I must own to some scepticism, and consequently do not see the special difficulty propounded as to accounting for them otherwise than by a lake. Perhaps it is only meant that they reach up from the river-level at one place to the 100 feet contour at another, which is a different matter; but, as a rule, they do not reach that level, at about which gravel of a higher terrace sometimes comes on. In saying that "the Crayford beds probably represent the complete series" of the Valley Drift, the author seems to leave this terrace out of the question.

A table of the distribution of Mammalia in our River Drifts, by Mr. E. T. Newton, precedes the elaborate table of the Mollusca, with its fourteen localities for Recent and Neolithic, and its five for River Drift, all but one of the former of which (Staines) may be claimed as in one district.

We have to thank the author for his laborious revision of old lists, as well as for his notes on the shells and their localities.

W. J. L. Abbott. "Notes on Some Pleistocene Sections in and near London."‡

The first section is at Whitefriars. It showed made ground, Alluvium (sand, with shells, and peat), gravel and London Clay, and other more or less neighbouring sections are alluded to.

* *Essex Naturalist*, vol. v, pp. 109, 133.
† *Proc. Geol. Assoc.*, vol. xi, no. 8, pp. 335-388, folding table.
‡ *Ibid.*, vol. xi, no. 1, pp. 473-480.

Then we are taken to West Thurrock; but the author is in some error as to sites. His section cannot be as much as four miles west of Grays, and the nearest similar sections that have been described are not east of that place, but about 1½ miles to the west of it, at West Thurrock.*

The section shows the abrupt ending-off of the River Drift against the Chalk, which is so remarkable at West Thurrock. The composition of the gravel is noted and the succession of beds above described (sands, clays, and gravel).

A mass of crushed ivory was found, as well as shells and bones.

1891.

DR. H. HICKS. "On some Recently-Exposed Sections in the Glacial Deposits at Hendon."†

Gives the results of twenty years of observation around his dwelling-place, culminating in the data given by sewerage-works throughout part of the parish.

Some of the sections showed channels in the sand and gravel filled with Boulder Clay, which latter sometimes cuts through to the London Clay.

In one section there were patches of gravel enclosed in the clay, which "must have been torn off as frozen masses from underlying beds and re-deposited as boulders in the clay."

As at places in Finchley, so here there is a brown clay, like London Clay, in or above the gravel. I remember seeing some of this, with Dr. Hicks, and noticing how readily it might sometimes be mistaken for London Clay, until a section was carried through it to underlying gravel.

The extension of the Glacial Drift is alluded to, and it is concluded "that the physical features of this part of N.W. Middlesex were moulded at a very early stage in the Glacial period, or clearly previous to the deposition of the so-called Middle Sands and Gravels" beneath the Boulder Clay; but when it is added that "the evidence clearly points to the conclusion that the implement-bearing deposits on the higher horizons in the Thames Valley should be classed as of contemporaneous age with these undoubted Glacial deposits" I must part company with my old friend, the evidence seeming to me to be precisely the other way.

The value of this paper is greatly enhanced by the map, on the scale of six inches to the mile, showing the extent of the Glacial Drift and the site of the many sections seen.

Dr. Hicks made some supplementary remarks on this subject

* There is an error in "The Geology of London," vol. i, p. 418, where one of these is described as south of "Mill Wood and West Thurrock," which should be "Mill Wood, West Thurrock."

† *Quart. Journ. Geol. Soc.*, vol. xlvii, pp. 575-584, pl. xxii.

on two occasions; firstly, in a paper of which only a short abstract has been printed, "On some Lacustrine Deposits of the Glacial Period in Middlesex,"* and secondly at a meeting of the Geological Society when there were no papers.† On the same occasion Prof. Watts noticed Drift sections at Carshalton, of which a fuller account was given later (1899).

H. B. WOODWARD. "Note on a Greywether at Bayswater."‡

Records the finding of a large stone, 9½ feet in length and breadth. and over 2½ in thickness, "in the basement portion of the Thames valley-gravel" in Moscow Road, and claims for it the credit of being the largest found in that deposit.

1892.

C. REID. "The Pleistocene Deposits of the Sussex Coast."§

Reference is made to the Valley of the Thames (pp. 359, 360), and it is suggested that our gravels may, like "similar sheets in Sussex," be "not river-gravels, but frozen-soil gravels, laid down on plains sloping gently towards the River Thames. They may have been deposited at all heights contemporaneously," and it is claimed that this view "will greatly simplify the geology of the district." That may be; but it does not get over the facts that there are differences in the gravels of different terraces, and that the divisions of the terraces are sometimes very marked, though sometimes not so, according to local circumstances. This theory seems to need one continuous slope of gravel, not two or three disjointed slopes. The terraces are there, and have to be explained, whatever may be the origin of the gravel.

T. V. HOLMES. "The New Railway from Gray's Thurrock to Romford."‖

Some of the sections referred to have an important bearing on the reading of the Thames Valley Drifts. In a cutting at Hornchurch a shallow hollow in the London Clay was found, filled with Boulder Clay, whilst over the whole was the sand and gravel of the highest terrace of the River Drift, clearly showing that this last is newer than the Boulder Clay, and still more so therefore the deposits of the lower and later terraces, unless, of course, as some geologists have suggested, the higher terraces are not the older, a view which I hardly understand. It seems to me that one piece of direct evidence like this is worth any amount of strong opinions or ingenious theories.

* *Rep. Brit. Assoc.*, 1894, p. 659, and *Geol. Mag.*, dec. iv, vol. i, p. 465.
† *Quart. Journ. Geol. Soc.*, vol. liv, pp ii, iii (1898).
‡ *Geol. Mag.*, dec. iii, vol. viii, pp. 119-121.
§ *Quart. Journ. Geol. Soc.*, vol. xlviii, p 344.
‖ *Ibid.*, vol. xlviii., pp. 365-372.

DR. H. HICKS. "On the Discovery of Mammoth and other Remains in Endsleigh Gardens, Gordon Street, Gordon Square, and Tavistock Square, London."*

This paper is a good example of what should be done to record those very short-lived sections on which our knowledge of the surface-geology of a great city so largely depends. In this, as in his paper of the year before, our former President showed that though he had been accustomed to take up large questions regarding vast formations, he could also, with equal zeal, apply himself to the observation of what some might think the petty details of sections in the London streets. May his example be a fruitful one!

From frequent visits to the excavations for sewers in the places named, he was enabled to draw four lines of section, all marked on the map in the paper: Through Endsleigh Street and along the W. side of Tavistock Square; along the S. side of Endsleigh Gardens; along the S. sides of Tavistock and Gordon Squares; through Gordon Street and along the W. side of Gordon Square. The beds shown were as follows, grouping the various sections:—

MADE GROUND, or disturbed ground as it is called, 5 to 16 feet. In one place cutting through to the London Clay.

RIVER DRIFT (as I should call it).	Yellowish-brown, &c., clay, with race, flints, &c., 2 to 10 feet.
	Loamy sand, 1 to 3 feet.
	Yellowish sandy gravel, with bones, large masses of sarsen-stones, a few pebbles of quartz and quartzite and Lower Greensand fragments, 3 to 9 feet.
	Dark clayey loam, with many seeds, and two freshwat[er] species of shells (by mistake noted as land-shel[ls] p. 458); a thin inconstant layer.

LONDON CLAY.

The Mammoth remains were found in the dark loam wi[th] seeds, and this bed it should be noted seems to have occurr[ed] only where there are slight hollows in the London Clay. T[he] seeds, which have been determined by Mr. C. REID, are those [of] plants "usually found in marshy places or ponds," and "there a[re] no typically Arctic plants, but . . . such as extend . . from the Arctic Circle to the South of Europe." The discove[ry] of this thin and peculiar bed was, I believe, a new point in Lond[on] Geology.

When Dr. Hicks leaves his facts and takes to inferences I a[m] forced to join issue with him, and very sorry I am that this has t[o] be done after he has left us, for no one acknowledged the right of others to differ from him more than our former genial President, who indeed, I think, delighted in geologic controversy. I cannot

* *Quart. Journ. Geol. Soc.*, vol. xlviii, pp. 453-468.

see that because the deposits may resemble, even in a marked manner, the Glacial deposits of Finchley, etc., it follows that they are of Glacial age; but I agree with Mr. Monckton, who, in the discussion, expressed his opinion that these deposits are newer than the Boulder Clay. The stratigraphic evidence for this view seems to me so strong that there is no reason to give up the opinion which I have always expressed, that the River Drift of the Thames Valley is Post-Glacial, that is of course in reference to the Boulder Clay of the border land; and I see no reason to class the particular deposits so well described by Dr. Hicks, otherwise than with the River Drift. I am glad to find that another predecessor in this chair, Mr. Hudleston, agrees in classing these beds as Post-Glacial.*

In a later note Dr. Hicks speaks of the bed beneath the bones (that is to say the loam with plants) as Pre-Glacial.† This is a misapprehension. In the first place it seems to assume that the beds with bones are of Glacial age, and then it certainly implies that any bed beneath a member of the Glacial *Drift* must be Pre-Glacial, whereas it may be simply a lower bed of Glacial Drift. This latter error, unfortunately, is rather common.

W. J. L. ABBOTT. "The Section exposed in the Foundations of the New Admiralty Offices."‡

The title of this paper is open to criticism, as the section was not in the foundations, but in the excavations for them; and that is almost the only fault I will find with this second contribution of the sort from the author.

The general section was as follows, the highest three beds filling a hollow to the south:—

ALLUVIUM	Silt, with bones, fragments of Samian ware, and, higher up, fragments of later date.
	Peat, with shells.
	Sand.
RIVER DRIFT	Sandy gravel.
	Dark brown marl, with intercalated gravel.
	Sandy gravel and sand.
	Dry land surface (? clay and marl), with land-shells and plants, and some small worked flints.
	Sand, with land and freshwater shells.
	Gravel and sand; often a layer of boulders (= large stones) at base, plants, divers marine shells in sand at bottom. Worked flints in gravel; also mammalian remains.
LONDON CLAY, fairly fossiliferous.	

I am answerable for the bracketed classification, but it is

* *Quart. Journ. Geol. Soc.*, vol. xlix, *Proc.*, p. 69 (1893).
† *Geol. Mag.*, dec. iii, vol. x, p. 90 (1893).
‡ *Proc. Geol. Assoc.*, vol. xii, pts. 9, 10, pp. 346-356.

sometimes a little difficult to collate the remarks in the text wi the figure, which is without references to the beds.

Of the more notable fossils was a bird-bone, from the Lond Clay; leaves of *Betula nana* from the sand at the base of t Drift (which MR. C. REID says "is a most interesting find, bei the first Arctic plant yet found in the Thames Valley"); and p of a Chelonian, appaiently from the lower marl.

Lists of the fossils are given, and in the case of the Mollus those new to the Pleistocene (4) and to the Thames Valley (are marked.

The author's concluding remarks as to the avoidance of w theories, sometimes started to account for deposits and phenome such as those described, are by no means needless.

This communication is followed by a note "On the Occ rence of Walrus in the Thames Valley,"* in gravel beneath t peat between Leadenhall and Fenchurch Streets.

1893.

H. W. MONCKTON. "On the Occurrence of Boulders a Pebbles from the Glacial Drift in Gravels south of t Thames."†

A paper calling for notice here, although for the most p referring to places which are away from London, in the wid sense of the term; but Wimbledon at all events is London, a red quartzite pebbles were found in high gravel there (p. 31 The author concludes that if a river "flowing in the direction the present Thames . . . existed at the time when Glacial Gravel was spread out," the valley in which the ri flows has, "to a large extent, been excavated since."

T. V. HOLMES. "The New Railway between Upminster a Romford."‡

Gives some further details of the Hornchurch cutting, arg for the Post-Glacial age of all the Thames Valley Drifts, includ those described by Dr. Hicks (1892), and alludes to difficulty of distinguishing river-terraces cut in such soft beds as London Clay. The author thinks that the presence of Boul Clay so low as at Hornchurch (about the 100 ft. contour) does show that the Valley of the Thames is of Pre-Glacial age, only "that there once was probably a hollow or valley para with that of the Ingrebourne, having a direction from nort south . . and that the Boulder Clay more or less occup this hollow." I see no difficulty in this: we know that Boulder Clay often rests most irregularly on the beds bene sweeping down fairly sharply from high to low levels, and t

* *Proc. Geol. Assoc.*, vol. xii, pt 10, p. 357.
† *Quart. Journ. Geol. Soc.*, vol. xlix, p 308.
‡ *Essex Naturalist*, vol. vii, pp. 1-14.

the Valley of the Thames, in its long course, should somewhere cut across some such irregularity is no more than should be expected.

T. H. WILSON. "Notes on the Gravel in Epping Forest."*

A record of new sections at Copt Hall, High Beech, Chingford, and Buckhurst Hill, and of the rocks found in the gravels, this latter subject being supplemented in a later note.†

H. W. MONCKTON. "On the Gravels near Barking Side, Wanstead, and Walthamstow."‡

Various sections are described, and the composition of the gravel in them noted. What I will call a most orthodox view of the succession of the Drift beds of the neighbourhood is given. The finding of a Lower Silurian pebble, with casts and impressions of *Orthis budleighensis*, is notable, and this is inferred to have come from a northern source; but Lower Greensand chert probably came from the south.

The same author's "Geological Notes on the Neighbourhood of Ongar,"§ with its many descriptions of sections, I can conveniently rule as just outside my vague boundary.

1894.

T. V. HOLMES. "Further Notes on some Sections on the New Railway from Romford to Upminster." ||

The conclusions of 1892 are strengthened by the description of a second cutting showing Boulder Clay beneath the gravel of the highest terrace. The conclusions of Dr. Hicks as to the age of the Endsleigh Street Drift are reviewed, and it is pointed out that the beds are like those of the River Drift elsewhere, and "that the position of these . . . beds is one in which river drift would naturally be expected, and where the representatives of beds which exist 5 miles away, and 200 feet above the sea [instead of 80], certainly would not be."

In the discussion, MR. L. ABBOTT says: "The Boulder Clay was coincident with the present valley, and occurred at various heights down to about 50 feet on the northern side, and lower still on the southern side." This I fail to understand. The only Boulder Clay yet found that can be said to be in the Thames Valley is fairly high up on the northern side, the lowest being the patches described by Mr. Holmes, at about 100 feet; whilst on

* *Essex Naturalist*, vol. vii., pp. 74-75.
† *Ibid*., p. 129.
‡ *Ibid*., pp 115-120.
§ *Ibid*., p. 87.
|| *Quart Journ. Geol. Soc.*, vol. l, pp. 443-452; Discussion, pp. 460-462.

the southern side not a speck of Boulder Clay has been found. Mr. Abbott must use the term in a sense different from the accepted one, possibly for deposits which he thinks to be of the same age as the Boulder Clay; but such use is simply begging the question.

DR. J. R. LEESON and G. B. LAFFAN. "On the Geology of the Pleistocene Deposits in the Valley of the Thames at Twickenham, with Contributions to the Fauna and Flora of the Period."*

The section shown along about a mile of cutting for a sewer is recorded, a work of a very commendable kind, as evidence from such a source is soon hidden. It were well if a law were passed compelling local authorities to keep such records.

In two parts, toward the Thames, London Clay was reached below the gravel. Elsewhere there was a dark loamy bed in that position, a bed like that recorded by Dr. Hicks as at the base of the gravel at Endsleigh Street; but differing from this in that gravel was found beneath in two sump-holes.

Lying on the loam, as at Endsleigh Street, were many mammalian bones (8 species), but no flint implements have been found. In the loam were found 8 species of freshwater shells and 14 of plants, the whole of species still living in the neighbourhood, and half the species of seeds being the same as those from Endsleigh Street. But "the vertebrates are very different, *cervus elaphus* being the only one common to both sections." Nevertheless, it seems almost a wonder that someone has not claimed these deposits as Glacial.

When the authors divide this thin deposit into four zones, one begins to think that even zonal classification may be pushed too far.

A note of the discovery of the Saiga Antelope here appeared in 1891.†

T. V. HOLMES. "The Geology of the Lea Valley."‡

A general sketch, with allusions to the eastward shifting of the lower part of the river, and to the Post-Glacial age of the valley, with its deposits of gravel and brick-earth.

W. G. SMITH. "Man the Primeval Savage." 8vo. London.

Chap. xv., entitled "Traces of Primeval Man from Tottenham to the Junction of the Lea with the Thames" (pp. 189-298), gives a full account of the finds of flint implements, etc., in that part of our district, with occasional digressions and with many figures, in the author's well-known clear style.

* *Quart. Journ. Geol. Soc.*, vol. l, pp. 453-462.
† *Geol. Mag.*, dec. iii, vol. viii, p. 94.
‡ *Essex Naturalist*, vol. viii, pp. 198-201.

1895.

E. T. Newton. "On a Human Skull and Limb-bones found in the Palæolithic Terrace-gravel at Galley Hill, Kent."*

A paper of general interest as regards the gravel of the Valley of the Thames. To the palæontological and chief part I need not refer; our interest centres in the finding of human remains in the gravel of the high terrace at Swanscombe, remains which may be of the age of that gravel, and not of later introduction. That, unfortunately, is all that we can say; but it is enough to ensure our interest and to stimulate further research. As flint implements were also found, there is, of course, no need for the occurrence of human bones to prove the existence of man at the time when the gravel was deposited, nor can there be any doubt as to what gravel we are dealing with.

Mr. Newton again alluded to this subject in his Presidential Address to us in 1898.

J. A. Brown. "The Last Stages of the Great Ice Age in the Neighbourhood of Ealing."†

Naturally a sketch of the subject, and apparently covered by the next paper.

J. A. Brown. "Notes on the High-level River Drift between Hanwell and Iver."‡

The author thinks that some of the deposits are not of simple fluviatile origin, but that they contain much ice-borne material. For these he proposes the term Fluvio-Glacial, and would include in them some deposits that have been coloured as Glacial on the Survey Map.

A section at Hanwell, with furrows in stratified gravel, is figured, the positions of flint implements found in one of the furrows being marked; and another Hanwell section is described as showing "contorted unstratified drift above stratified beds."

We are then taken by Southall to Hayes, Uxbridge, and Drayton, many sections being described and implements noted; but we are getting beyond our bounds, and may pass by these and sections at Iver.

The author thinks that a thin ice-cap would be enough for the formation of this Fluvio-Glacial Drift, and that "this minor glaciation was of a local character." He believes that "the stratified, implementiferous drift beneath the unstratified deposits" is an older formation, and that man "was at least contemporary

* *Quart. Journ. Geol. Soc.*, vol. li, p. 505.

† ? Privately printed, 8vo, pp. 11. Abstract of a Lecture to the *Ealing Nat. Sci. Micr. Soc.*

‡ *Proc. Geol. Assoc.*, vol. xiv, pt. 4, pp. 153-173.

with the last stages of the glacial period in the valley of the Thames." For my own part I hesitate to call in such strong glacial conditions to account for small superficial irregularities.

1896.

T. V. HOLMES. "A Sketch of the Geology of Epping Forest." *

This is described by its title, a merit not by any means universal.

Another contribution from the same author, entitled "Notes on the Ancient Physiography of South Essex," † is concerned with the relation of the geology to the features of the country, and is, of course, far beyond London in great part.

A. E. SALTER. "Pebbly Gravel, from Goring Gap to the Norfolk Coast." ‡

The High Level Gravels of the Thames Valley are described under five types, according to their constitution. Of these, the Barnet Gate type has been noted in our district, at Shooter's Hill and Horsington. The Hampstead type occurs at Totteridge, as well as at Hampstead. The High Barnet type is noticed no nearer than our borders, and the Bell Bar type just beyond. Lastly comes the Glacial Gravel, which of course occurs at Finchley; but I doubt whether that of Dartford Heath is properly so classed.

With the other (East Anglian) gravels we are not concerned.

The author contends that the pebblygravels (first four types) did not originate as a beach which has been gradually lifted to the N.W., but that they are "the first instalments of transported material usually ascribed to Glacial . ." agency, and that they have come through gaps (in the chalk) which are described, and he suggests the name "Early Drift . . ." for these, the first deposits of the Glacial Series.

It seems to me that these unhappy beds have names enough already, and I feel thankful that my days of Drift-mapping are over, lest I should be expected to divide where I have mostly tried to group. I take it, however, that MR. SALTER'S names mostly refer to the composition, etc., of various gravels of the same age, and do not suggest divisions.

1897.

C. REID. "Pleistocene Plants from Casewick, Shacklewell, and Grays." §

Of this short paper, a third certainly belongs to London, and another third may be conveniently included.

* *Essex Naturalist*, vol. ix, nos. 15-22, pp. 160-165.
† *Ibid.*, pp. 193-200, folding map.
‡ *Proc. Geol. Assoc.*, vol. xiv, pt. 9, p. 389.
§ *Quart. Journ. Geol. Soc.*, vol. liii., pp. 463, 464.

The Shacklewell plants are from a peaty clay got "by Prestwich from beneath 8 or 10 ft. of gravel; but neither the mollusca nor the plants point to any great antiquity of the deposit, characteristic Pleistocene forms being absent."

The Grays plants "consist of a number of leaves, . . . and some seeds," and they "occur associated with, or below, the remains of mammoth and *Corbicula fluminalis*. They point distinctly to a temperate climate and mild winters. . . . Both the character of the flora and the position of the deposit suggest correlation with the temperate plant-beds of Hoxne, which lie between the Boulder Clay and the deposit with Arctic species." The ivy and the poplar are here first recorded as fossils.

We may be thankful that the author, like the deposit, is temperate, and does not claim for the latter Glacial age. It is quite a relief to have these beds left as Post-Glacial!

A. S. KENNARD and B. B. WOODWARD. "The Post-Pliocene Non-Marine Mollusca of Essex." *

Amongst the beds referred to are those at Canning Town, Walthamstow, the Victoria etc. Docks, Grays, West Thurrock, and Ilford, the Molluscan contents of which are listed. This is a revision of all previous records; not for our district alone, however, and not only for Drift, but also for the more recent Alluvium.

DR. G. J. HINDE. "Notes on the Gravels of Croydon and its Neighbourhood." †

We are glad to find Dr. Hinde able to tear himself away from the attractions of the microscope, and return to an old love, the Drift, though of old he wrote of American deposits.

He gives an account of the physiography of the Basin of the Wandle, and then describes the gravel in the Caterham Valley, beginning at Whiteleafe, where he found remains of mammoth rhinoceros, horse, ox and reindeer. Continuing down this valley the gravels at Kenley and at the junction with the main valley at Purley are described. At Whiteleafe and Purley masses of Tertiary conglomerate, of flint-pebbles, are found in the gravel.

The Hooley valley, or that along which the Brighton Road runs, is next taken in hand, and it is pointed out that Lower Greensand fragments in the gravel need not have come direct from that formation, on the south, as suggested by Prestwich (1890), as they occur also on the high ground bordering the valley, which "shows that they must have been brought into our drainage area before this valley was formed, and that probably they found their way into the gravels from the erosion of the plateau clay-with-flints."

* *Essex Naturalist*, vol. x, pts. 4-6, pp. 87-109, 189, folding table.
† *Trans. Croydon. Micr. Nat. Hist. Club*, 1896-97 (vol. iv), pp. 219-233.

The Chipstead valley is then noticed, with the high level gravel of Walton, etc., which is classed with the Southern Drift, and is the only mass of this "known within the Wandle drainage area," except at Norwood. The thin gravel of the valley-bottom is also described.

The gravel of the combined valleys, along the Brighton Road, to Croydon comes next. Various sections are described, and the blocks of conglomerate are noticed, the author saying of them that he does "not know of any beds of similarly cemented rock in the Blackheath deposits yet remaining in our area. They have evidently travelled some distance to produce their smooth worn surfaces, and it must have required a current of water of considerable volume and force to transport them down valleys of such slight fall as those in which they now occur." Of this I do not feel so sure. We are not so much dependent on what we can see in the remains of the Blackheath Beds in the neighbourhood, but should remember that these are of much less extent than the great amount of the formation which has been swept away.

Up to this we have been dealing with the comparatively narrow valleys of the Chalk; but at Croydon the oncoming of the Tertiary beds leads to the widening of the valley of the Wandle, and to consequent wide-sheets of gravel. Various sections in Croydon are described, and then those of Mitcham, in one of which the remains of mammals, of like kind to those at Whiteleafe, have been found, whilst roebuck is added at another.

The flints that form the chief constituent of these Valley Drifts are of five sorts: those that have come direct from the Chalk, or from the Clay-with-flints, and are either hardly worn or subangular; similar flints, brown outside, that have come from high-level gravels; flint fossils; flint pebbles, from the older Tertiary beds; and green-coated flints, from the base of the Thanet Sand. The other stones are pebbles of quartzite, from the Blackheath Beds (in which they are rare, as also in the gravels); fragments of iron-sandstone, either of Tertiary or Lower Greensand age; and rounded fragments of porous chert, from the Lower Greensand. No pebbles of quartz or of other quarztite than that mentioned, or of other old rocks have been found in the gravels of the Wandle area.

The theory of C. Reid that such gravels were formed at a time when the surface-beds of the Chalk were permanently frozen, so that they would be eroded as non-porous rocks are, is accepted; but the author thinks that "there is no evidence of any glacial action in the valley gravels," though it is "possible that ice may have assisted in the removal of some of the larger blocks."

He concludes that "the formation of the valleys and the gravels appears to have been carried out entirely by subaerial action: there is nothing to indicate any submergence and subsequent upheaval either during or since their formation. . . . The local character of the gravels . . . has an important bearing on this point, for they contain only those materials which are known to have been present within the Wandle drainage area before the valleys began to be excavated in the chalk plateau."

N. F. ROBARTS. "On the Occurrence of Mammalian Remains near Purley."*

A fitting supplement to the last paper, recording a new railway-cutting close to Purley Station, through a small patch of Drift, a little above that in the bottom of the valley. The deposits consisted of two beds of brick-earth, gravel, and chalk-rubble. The remains, of which many were found, were those of the mammoth and ox.

I feel somewhat elated that this wee patch of Drift is shown on the Geological Survey Map, Sheet 8, as there is no other section in it.

SIR J. EVANS. "The Ancient Stone Implements . . . of Great Britain." Second Edition. 8vo. London.

It is with the latter part only of this work that we are concerned, "Implements of the Palæolithic Period"; but it is especially in this that additions have been made, and all that needs to be said here is that the records for our district are brought up to the latest.

1898.

Memoranda chiefly on the Drift Deposits . . . being extracts from the . . . MSS. of the late Sir Joseph Prestwich.†

These contain notes made many years ago, but which had not been printed. Under the heading "Thames Valley and Eastern Counties" are many entries from note-books that concern us (pp. 406-410), accounts of sections at Kensington, Chelsea, Shepherd's Bush, Ealing, Clapham and Wandsworth Commons, Highbury, Wood Green, Stoke Newington, Grays, and Braintree.

A. E. SALTER. "Pebbly and other Gravels in Southern England."‡

The greater part of this elaborate paper refers to parts beyond our bounds; but the "Early Drifts" of 1896 are again noticed. There is a slight error in their description as "at heights varying from 400 feet O.D. . . . to over 600 feet," as two localities at

* *Trans. Croydon Micr. Nat. Hist. Club*, 1896-97, vol. iv, pp. 233-5.
† *Geol. Mag.*, dec. iv, vol. v, p 404.
‡ *Proc. Geol. Assoc.*, vol. xv, pt. 7, p. 264.

300 feet are noticed. This gives a pretty wide range in height. Swanscombe Hill and Norwood are added to our localities.

The Lower Plateau Drifts, with which Glacial Drifts are included, are exemplified at the high ground of Ealing, Kingston Hill, Richmond Hill, and Wimbledon Hill.

The term River Drifts seems to be applied only to terraces lower than the above.

J. P. JOHNSON. "Pleistocene Drift of Thames Valley."*

A general account of the River Drift, which gave rise to some comments and corrections, in the following paper.

1899.

A. S. KENNARD. "Pleistocene Beds of Lower Thames Valley."†

When the author objects to Mr. Johnson's statement that these beds are "locally post-glacial," as misleading, I must differ from him. That only means that they are newer than the Boulder Clay, which the author allows. That the gravels of the Thames were deposited during a cold period is not the same thing as saying that they are of Glacial age. It is perhaps unfortunate that the same word is used for conditions, and (with a capital G) for a period; but so it is.

Presumably it is on account of the indefiniteness of the subject that both these authors object to the definite article in their titles.

W. WHITAKER. "On a Drift Deposit at Carshalton, and on Sections shown by Cuttings for the Sewers. With a Note on the Mammalian Remains by E. T. NEWTON."‡

The Drift with bones is mostly sand, and is not shown on the Geological Survey Map, as there was no section to be seen before the sewage-works were begun. It differs from the rest of the Drift in the neighbourhood, which is gravel, and was found to be 18 feet deep at one place. The bones were close to the bottom in a loamy peaty bed, and amongst them was a skull of *Rhinoceros antiquitatis*. In the sewers, Gravel, London Clay, Reading Beds, Thanet Sand, and Chalk were seen.

Bones of elephant and of horse were also found, besides those of *Rhinoceros antiquitatis*.

"The Life and Letters of Sir. Joseph Prestwich" contains many references to the neighbourhood of London, and probably some matter not published before.§

* *Science Gossip*, vol. v, no. 55, pp. 194, 195.
† *Ibid.*. No. 57, pp. 264, 265.
‡ *Trans. Croydon Micr. Nat. Hist. Club*, 1898-99 (vol. iv), pp 288-293.
§ 8vo. London. See pp. 69-72, 133, 166, 205, 206, 294.

1900.

G. CLINCH. "Note on Drift-gravels at West Wickham (Kent)."*

Two deposits are referred to. Firstly, a gravel in the bottom of the valley on the southern and western sides of Hayes Common, and secondly, a gravel in parts of the sides and bottom of a short tributary valley.

Some of the gravel is not shown on the Geological Survey Map (presumably because there was no good evidence of it when the map was made); but the chief interest of the deposits is the occurrence of Palæolithic implements, of which the author found many, some much worn, others unworn. He thinks "that the Drift-implements have received their ochreous colour from some chemical change in themselves rather than from their environment."

H. B. WOODWARD. "A Greywether at South Kensington."†

Records a find, 10 feet down in gravel, in the excavation for the Victoria and Albert Museum. It is smaller than the one recorded in 1891, and is estimated to weigh from 13 to 14 cwt. It will be preserved in the garden of the National Museum, close to its place of burial.

J. P. JOHNSON and G. WHITE. "Some New Sections in, and Contributions to the Fauna of, the River Drift of the Uphall Estate, Ilford."‡

A re-opening of the section here showed a fossiliferous bed of sand, and enabled the authors to make a large collection of Mollusca, adding 15 species to those before recorded, to which another is added in a postscript. Of these "*Arion ater* is entirely new to the Pleistocene, and *Helix hortensis* to the Thames Valley Brickearths." Moreover, they "have been able to verify four records of which no specimens were known."

M. A. C. HINTON. "The Pleistocene Deposits of the Ilford and Wanstead District."§

The High Terrace Drift at Wanstead and Barkingside is described, with contorted beds over undisturbed gravel, the contortion possibly caused by the melting of an ice-raft on a shoal. The gravel contains large "and apparently ice-worn foreign rocks."

The Middle or Low-Terrace Deposits are then noticed, most of the sections being at Ilford, and open in the years 1893-99. A

* *Quart Journ. Geol. Soc.*, vol. lvi, pp. 8, 9.
† *Geol. Mag.*, dec. iv, vol. vii, pp. 543, 54.
‡ *Essex Naturalist*, vol. xi, nos. 10-12, pp. 157-160.
§ *Proc. Geol. Assoc.*, vol. xvi, pt. 6, pp. 271-281.

list of the Vertebrata from two of the pits is given. The High-level Drift contains but one southern shell, *Corbicula fluminalis*; but the richer fanna of the low-level brick-earth includes southern mammalia. His conclusions as to the conditions under which these deposits were formed are given under the next and later paper.

"On the Pleistocene Deposits of the Ilford and Wanstead District." *

This is supplementary to his paper to the Association. He describes some new sections, and concludes that the Drift of the High Terrace and some of the Middle Terrace "represent a time during which the climate was severe enough for the Thames to be periodically frozen over," a very moderate amount of glaciation, to which no exception can be taken. But he thinks that "the Middle Terrace Drift as a whole" represents "a period of comparative equability" like that of our own time.

A. S. KENNARD and B. B. WOODWARD. "The Pleistocene Non-Marine Mollusca of Ilford."†

Chronicle additions made in the last four years, and compare the lists from two pits. As these differ considerably it seems to me that we should not be hasty in drawing conclusions from like differences at distant places. A single example of *Helicella virgata* is the only one found in any deposit in the Thames Valley, and other rarities still further enforce the danger of trusting to negative evidence.

A. RUTOT. "Note sur la Position stratigraphique de la *Corbicula fluminalis* dans les Couches quaternaires du Bassin Anglo-Franco-Belge."‡

The Basin of the Thames is treated of in pages 2-8, as "the typical region," and the author's notes were made during the excursion which this Association arranged for our Belgian friends in 1899.

He concludes that, instead of being one deposit, the Drift of the Erith pits consists of loam of Hesbayen age over the *Corbicula*-beds.

In the bed of flints, rolled and otherwise, between the loam and the *Corbicula*-beds, he found flints which he classed as worked by man, whilst the *Corbicula*-beds give evidence of a still older industry.

He regards the *Corbicula*-beds as Interglacial in age, or between the Till and the Upper Boulder Clay, taking the place of the "Middle Glacial."

* *Essex Naturalist*, vol. xi, nos. 10-12, pp. 161-5.
† *Proc. Geol. Assoc.*, vol. xvi, pt. 6, pp. 282-6.
‡ *Mém. Soc. Belge de Géologie*, t. xiv, fasc. 1, p. 1.

These conclusions are practically repeated in the "*Compte rendu de la Session annuelle extraordinaire de 1899 tenue dans le Bassin de Londres . .*"* in which the excursion is fully described, and a thin mass of contorted beds above undisturbed loam, etc., is noticed as further evidence for the division of the Drift above-noted (Hesbayen, Campinien, and Moseen).

It seems to me that any slight differences of age in such beds are hardly enough to warrant the use of different place-names, names that may lead us to make too much of small divisions.

J. P. Johnson. "Palæolithic Man in Valley of the Wandle." †

Having lately noticed this paper (in an Address to the Croydon Micr. Nat. Hist. Club) there is no need to do more than enter it here.

1901.

E. T. Newton. "British Pleistocene Fishes."‡

Records otoliths, teeth or bones of ruff, pike, roach, dace, rudd and eel from Grays.

With this satisfactory menu for our palæolithic forefathers, my long review comes to a close.

5. CONCLUSIONS.

In ending this sketch of the Geology of the Drift in and around London, as described during the last twelve years, I would like to note some of the impressions that are left on my mind.

Firstly and generally, it might have been thought that the appearance of a work which attempts to give an exhaustive account of the geology of a district would act, for a time at least, as a sort of stop in the investigation of that district. But it is not so, rather the reverse, for in this case the work in question was speedily followed by papers of much interest. Such a book seems to form a starting-point for future work, for not only does it show us what has been done, but also what has not been done; it practically, though silently, suggests objects for inquiry and for discussion. This is what should be the case, and I take it as a good thing that a work of the sort should, apparently, result in starting a multitude of observers to supplement and to correct it.

Then, as regards the Drift, there seems to me to have been a leaning to over-refinement, and a tendency to over-division of the beds, which lead to the bewilderment of simple-minded persons like myself.

In such deposits as gravel surely we should expect differences

* *Mém. Soc. Belge de Géologie*, t. xiii., fasc. ii. p. 267 (1901).
† *Science Gossip*, vol. vii, pp. 69-71. See also pp. 177, 221, 233.
‡ *Geol. Mag.*, dec. iv, vol viii, p. 49.

of composition and of behaviour generally, and not always a wide spreading similarity; but seeing these differences, we have little right to argue therefrom that there are differences of age (of course, I mean in deposits similarly placed). A gravel brought from the east may differ much from one brought from the west, and yet the two may be of the same age and may have been produced by like causes.

Again, if we are to classify our Drifts from the direction of origin, every point of the compass may have to be represented and we shall have to make troublesome allowances for variation.

To my mind, it seems that in the case of our Drifts, though not alone in that, differences in condition are sometimes made too much of, in that they are taken as equivalent to differences of age.

Another notable point is an apparent desire to push back the age of some of our Drift beds, as if they became thereby of greater interest. To me a gravel of Post-Glacial age (using that term in a local sense, without reference to distant deposits) is no worse, and no better, than one of Glacial or of any other age. To some people, however, it seems otherwise, and adding a few thousand years to the age of a gravel has the effect of making that gravel of higher consideration than it was before. I suspect that often the unavowed cause of this is a wish to push back the antiquity of man, whose works are found in many gravels and loams. To this there is no objection, provided that it be done in the proper way; that is, that man's remains or his works be sought for and found in beds that are undoubtedly of older age, Glacial or otherwise, than those in which any have already been found. But when traces of man are found in any bed I cannot see why we should forthwith strain every point to show that this bed is older than had been thought before, especially when to do so seems to go against ordinary stratigraphic considerations, which some observers are inclined unwisely to ignore.

How the occurrence in any Drift of an existing species, like *Corbicula fluminalis*, extinct though it be in this country and in neighbouring lands, can prove any special antiquity I fail to understand. Truly it points to change of conditions and of a kind that imply lapse of time; but we are all ready to assign a very respectable age to nearly all our River Drift. How these particular *Corbicula*-beds can be older than the Boulder Clay puzzles me. They rest sometimes on a slope, part of which is cut though a higher terrace of gravel, and in other places what seems clearly to be part of that higher terrace of gravel rests in hollows cut in Boulder Clay. This gravel, therefore, being newer than the Boulder Clay, so much the more must the *Corbicula*-drift be.

Then, returning to generalities, there is the highly satisfactory fact that there are many good observers about, ready to record any sections that may be open, to examine their contents and to give us the benefit of their work; ready too, in the properly combative spirit of geologists, to discuss any view that has already been before us, and to start new views.

Lastly there remains with me the consoling impression that there is much more of this work to be done and that there are plenty of problems for our young geologists to solve. Let them remember that study in the field is the first point. *Solvitur ambulando* might be their motto.

May the next twelve years be as fruitful of good work in London Geology as those that have just passed. And may the century which has just dawned see our Association as active and as successful in this work as it has been in the latter part of the century that has gone.

6. APPENDIX.

PAPERS THAT ESCAPED NOTICE IN THE "GEOLOGY OF LONDON," &c., 1889.

1874. TOPLEY, W. "On the Correspondence between some Areas of Apparent Upheaval and the Thickening of Subjacent Beds." *Quart. Journ. Geol. Soc.*, vol. xxx (pp. 186, 190-195).

1878. BELT, T. "The Superficial Gravels and Clays around Finchley, Ealing, and Brentford. *Quart. Journ. Sci.*, July (45 pages).

1885. WOOD, S. V., JUNR. "On the Sand-Pit at High Ongar." *Trans. Essex Field Club*, vol. iv, pt. 1, pp. 76-82.

1886. TAYLOR, W. "On the Probability of Finding Coal in the South-east of England." Pp. ii, 22. Privately printed 8vo. Reigate.

1887. WARINGTON, PROF. R. "A Contribution to the Study of Well Waters." *Journ. Chem. Soc.*, vol. li, p. 5co.

1888. WILLIAMS, W. M. "The Chemistry of London Clay." *Trans. Middlesex Nat. Hist. Soc.*, Session 1887-88, pp. 7-15.

ANNUAL GENERAL MEETING.

FEBRUARY 8TH, 1901.

W. WHITAKER, B.A., F.R.S., President, in the Chair.

Messrs. M. A. C. Hinton and Henry Bassett were appointed Scrutineers of the ballot.

The following report of the Council for the year 1900 was then read:

THE numerical strength of the Association on December 31st, 1900, was as follows:—

Honorary Members	16
Ordinary Members—	
a. Life Members (Compounded)	160
b. Old Country Members (5s. Annual Subscription)	5
c. Other Members (10s. Annual Subscription). .	386
Total	567

During the year forty-one new members were elected. The Council regrets that the Association has lost fifteen members by death: John W. Bailey, William Law Bros, William L. Brown, Dr. Claude Claremont, James D. Hardy, Thomas C. Maggs, Henry N. Maynard, Charles J. A. Meÿer, George H. Morton, W. P. Sutherland, H. Virtue Tebbs, Rev. J. J. C. Valpy, Henry Walker, George Wilks, and T. Hay Wilson.

William Law Bros was a prominent member of the Camera Club, where he recently delivered a series of illustrated lectures on the Ancient Monuments of India. He was a well-known member of the Royal Society of Antiquaries of Ireland, and was one of the few English members of the Association Française, a body which he addressed in 1898 and again in 1900, when he assisted Prof. Geddes in arranging a series of Congresses at the Paris Exhibition.

James D. Hardy became a member of the Association in 1885, and served on the Council from 1895 to 1899. He was an industrious worker with the microscope, camera, and sketch-book, a member of the Queckett Club, and a constant attendant at the meetings and excursions of the Association. He had endeared himself to a large circle of the members, who will greatly miss his genial presence.

In Charles J. A. Meÿer the Association has lost an old friend, and one who has done much to further the knowledge of the Cretaceous rocks and fossils. One of his historic papers—that on "The Lower Greensand of Godalming"—was contributed to the Association in 1868. Many papers from his pen have appeared from time to time in the Quarterly Journal of the Geological

Dr. Income and Expenditure for the Year ending Dec. 31st, 1900 Cr.

	£	s.	d.
To Balance from 1899	58	16	7
" Life Compositions	42	15	0
" Admission Fees	18	10	0
" Annual Subscriptions	174	10	0
" Dividends on Nottingham Corporation Stock ...	28	1	2
" Sale of Publications	21	11	1
" Sale of "Record"	5	4	6
" Sale of "Paris Basin"	1	0	6
" Advanced by Dr. A. W. Rowe towards the publication of his paper on "The Zones of the White Chalk of the English Coast" ...	24	5	0
	£375	3	10

	£	s.	d.
By Printing "Proceedings"	119	7	9
" " Monthly Circulars	19	6	6
" Miscellaneous Printing	15	6	11
" Illustrating "Proceedings" and Circulars ...	17	11	7
" Postages	40	5	7
" Addressing	7	10	0
" Library (including Honorarium to Librarian of St. Martin's Library)	11	1	11
" Attendance, Lighting, Lantern, etc., at Evening Meetings	19	7	6
" Excursions	4	18	9
" Insurance	2	15	0
" Stationery	4	17	3
" Miscellaneous Expenses	1	10	2
" Purchase of £47 10s. Nottingham Corporation Stock, and Broker's Commission	50	0	0
" Balance at Bank of England, Dec. 31st, 1900	61	4	11
	£375	3	10

Due from Advertisement Contractor, Dec. 31st, 1900, £26 16s. 6d.

We have compared the above account with the vouchers, and find it correct.
We have also verified the investment of £984 14s. 2d. Nottingham Corporation Stock.

JNO. E. PIPER.
ARTHUR W. STIFFE. } *Auditors.*

January 15th, 1901.

Society, the "Geologist," and the "Geological Magazine." He was elected a member of the Association in 1862, and at various times acted as director of excursions. He was a careful and accurate observer, and an enthusiastic collector, and his kindly manner and willingness to impart information made him deservedly respected and esteemed by those who knew him.

George H. Morton was elected a member of the Association in 1879. He received the Lyell medal of the Geological Society in 1892, and was the founder of the Geological Society of Liverpool. The work by which he will long be remembered is "The Geology of the Country Around Liverpool," which, with its Appendix, gives the result of many years' study of the district. Papers on the Geology of North Wales and of the Liverpool district were contributed by him to various societies. He died on the 30th March, 1900, in his 74th year.

T. Hay Wilson joined the Association in 1881, and was the author of a paper entitled "Notes on the Artificial Unmaking of Flints," contributed to the Proceedings in 1889.

The financial position of the Association continues satisfactory. The income for 1900 was £291 12s. 3d., practically the same as in 1899, and the expenditure was £263 18s. 11d. This includes an outlay on the PROCEEDINGS, which is somewhat heavier than usual, owing to the publication of the paper by Dr. A. W. Rowe on "The Zones of the White Chalk of the English Coast" (Part I.). This, one of the most valuable papers that has appeared in the PROCEEDINGS for some time, was as to length and wealth of illustration rather beyond the usual scope of the Association's publications. The Council, therefore, voted a sum of £16 towards printing and illustrating the paper, and Dr. Rowe generously undertook to guarantee the balance. It was, however, felt that the value of the papers promised by Dr. Rowe on this subject was such that the Royal Society might be asked to contribute towards their publication out of their "Donation Fund." As a result of the application a sum of £50 has been promised towards the publication of this series of papers, an announcement which the Council feel sure will be appreciated by all the members of the Association. As was mentioned in the last Annual Report, the Council caused a sum of £50 to be invested in January, 1900, and having regard to the satisfactory balance they have again decided to hand over £50 to the trustees for investment. This sum, which represents rather more than the Composition Fees received during the year, has been invested in January of this year, and resulted in the purchase of £49 2s. 9d. Nottingham Corporation Stock, thus bringing the invested funds of the Association to over £1,000. The Council have been considering the unsatisfactory state of the Advertisement Contractor's Account, with the result that they have given him notice on of his contract. Other arrangements are now

ceedings published during the year 1900 consist of rs, containing seven plates and twenty-nine other The thanks of the Association are due to the their contributions, and especially to Dr. A. W. is paper on "The Zones of the White Chalk of the st" (Part 1, Kent and Sussex); also to Mr. J. E. is "Notes on the Geology of the English Lake For the loan of blocks, clichés and photographs used g the Proceedings, thanks are due to the following: Bather, Mr. F. Chapman, Mr. A. K. Coomara-Swamy, H. Preston, The Geological Society of London, and lshire Natural History Society.

nber of volumes in the library continues to increase, ugh exchange with other societies and institutions. een a marked increase in the use of the books at Library, and the number issued to members has more ed that of the previous year. Country members ppreciate the advantage of being able to borrow the cost of carriage.

owing is a list of the papers read at the evening

hætic Section at Bristol," by H. W. WICKES.

ural History of Phosphatic Deposits," being the address of the ent, J. J. H. TEALL, M.A., F.R.S.

n Pebbles in the British Isles," by F. A. BATHER, M.A., F.G.S.

l Features of the Chalk Pits in the Rochester, Gravesend, and s," by G. E. DIBLEY, F.G.S., with an Appendix on a Bone from Cuxton, by E. T. NEWTON, F.R.S.

the Geology of the English Lake District," by J. E. MARR,

es of the White Chalk of the English Coast, Part II., by DR. A. W. ROWE, F.G.S.

were delivered by F. W. RUDLER, F.G.S., on "The Eruption of Etna"; by H. W. MONCKTON, F.L.S., n "Some Features of the Recent Geology of Western and by Sir Archibald GEIKIE, D.C.L., LL.D., F.R.S., lder Sea-Margins."

nks of the Association are due to all these gentlemen. ersazione of a successful character was held in and a full list of the exhibits is published in the gs. Thanks are due to the many members who to the success of that evening.

owing Museums were visited in 1900:

.—The Museum of the Geological Society, Burlington House, direction of Mr. C. DAVIES SHERBORN, F.G.S.

The Mineral Gallery of the British Museum (Natural History), Road, under the direction of Mr. LAZARUS FLETCHER, M.A., The following is a list of the excursions made during the past year. Detailed reports will be found in parts 8, 9, and 10 of the PROCEEDINGS, vol. xvi :

DATE.	PLACE.	DIRECTORS.
April 12 to 17 (Easter)	Newton Abbot, Chudleigh, Dartmoor, and Torquay	Horace B. Woodward F.R.S., A. R. Hunt M.A., F.L.S., F.G.S. and W. A. E. Ussher F.G.S.
April 21	Thorverton and Ideston, near Exeter	F. G. Collins, F.G.S.
April 28	Wimbledon and Kingston	The President and H. W. Monckton, V.P.G.S.
May 5	Hitchin and Arlesey	William Hill, F.G.S.
May 12	Boxmoor	Upfield Green, F.G.S.
May 19	Hertingfordbury and Bayford	A. E. Salter, B.Sc, F.G.S.
May 26	Eastbourne	C. Davies Sherborn, F.G.S.
June 2 to 5 (Whitsuntide)	Malvern and District	Prof. T. T. Groom, M.A., D.Sc., F.G.S.
June 16	Caterham, Godstone, and Tilburstow	The President
June 23	Guildford	A. K. Coomara-Swamy, B.Sc., F.G.S.
June 30	Silchester	J. H. Blake, A.M.I.C.E., F.G.S.
July 7	Kettering and Thrapston	Rev. J. F. Blake, M.A., F.G.S., and Beeby Thompson, F.G.S.
July 14	Purley and Whyteleafe	The President and G. E. Dibley, F.G.S.
July 21	Winchfield and Hook	P. L. Sclater, Ph.D., F.R.S, and H. W. Monckton, V.P.G.S.
July 28	Grove Park	T. V. Holmes, F.G.S.
August 11	Netley Heath and Gomshall	W. P. D. Stebbing, F.G.S.
August 20 to 25 (Long Excursion)	Keswick	J. E. Marr, M.A., F.R.S.
Sept. 8	Stroud and Halling	G. E. Dibley, F.G.S.
Sept. 22	Orpington	T. V. Holmes, F.G S.

The average attendance at the excursions has been very good. A new departure has been made during the past year in regard to fares. Some disappointment having been experienced by members on certain occasions when the number present was not sufficient to secure the full reduction of fare, the Council decided as an experiment to guarantee the reduced fare for the excursions from May to September irrespective of the number of the party. This arrangement was duly carried out, and although it resulted in a small loss to the Association, it is thought that the loss would probably be still less if the arrangement were more generally known amongst the members. It is further considered that the advantage to members is sufficient to warrant the continuance of the experiment for another year, and it has therefore been decided to again guarantee the reduced fares for all day and half-day excursions during the coming season.

The thanks of the Association are due to the Directors of the excursions. and also to the following for assistance and hospitality:

Mr. and Mrs. A. R. Hunt, at Foxworthy, near Lustleigh; Colonel Walcott, at Chudleigh; the Torquay Natural History Society, at Torquay; Mr. C. D. Blake, at Newton Abbot; Messrs. Candy and Co., at Heathfield; the Society of Antiquaries and Mr. Mill Stephenson, at Silchester; Mr. G. Clinch, for keeping open the Exhibition of the Society of Antiquaries for an extra day on July 2nd; the Great Western Railway Company, at Ledbury; Mr. J. Postlethwaite, Mr. Harkowitz, Mr. E. E. Walker, and Captain Bawden, at Keswick.

Thanks are due to Sir Archibald Giekie, Director-General of the Geological Survey, for the presentation of the following sheets of the Geological Map of England and Wales: One-inch Nos. 98 N.W., 102 S.W. (Old Series), and 268, 284, 339, 350 (New Series).

The following Committee was appointed to arrange and carry out the excursion programme for the year: Mr. Bedford McNeill (Excursion Secretary), Miss Foley, Miss Whitley, Messrs. A. K. Coomara-Swamy, H. A. Hinton, F. Meeson, H. W. Monckton, A. E. Salter, W. P. D. Stebbing, and A. C. Young.

Owing to his absence from England, Mr. Bedford McNeill was obliged to resign his position as excursion secretary, and the Council, acting under Rule XIV., appointed Miss M. C. Foley to fill the vacant office. The thanks of the Association are due to the members of the above committee for the able manner in which they have carried out the arrangements for the excursions during the past year. The committee appointed to prepare an excursion programme for 1901 was constituted as follows:—Miss M. C. Foley (excursion secretary), Miss Whitley, Messrs. A. K. Coomara-Swamy, H. A. Hinton, J. W. Jarvis, F. Meeson, H. W. Monckton, E. P. Ridley, A. E. Salter, W. P. D. Stebbing and A. C. Young.

There are many changes in the House List. Mr. R. S. Herries has tendered his resignation as Treasurer, after having served the Association in that capacity for the last eight years, during which time he has always had the interests of the Association at heart, and has bestowed great care on its financial affairs. The Council feel that they are anticipating the wishes of the members in suggesting his name for election as a Vice-President. Mr. H. A. Allen now retires from the Editorship. For four years he has ably fulfilled the arduous duties of his office, and the Association is much indebted to him for the careful manner in which he has edited the PROCEEDINGS during that time. Mr. W. J. Atkinson also finds it necessary to resign his position as Librarian, and the thanks of the Association are due to him for the time and attention he has given to the care of the Library during the seven years of his office. Mr. Henry Fleck, who has been associated with Mr. Atkinson in the management of the Library, is recommended for election as Librarian.

Thanks are also due to Mr. E. T. Newton, who now retires from the Vice-Presidency and from the Council, and to Mr. G. C. Crick, who retires from the Council.

The names of those suggested by the Council to fill the vacant offices will be found on the ballot paper.

On the motion of Mr. T. V. Holmes, seconded by Mr. J. Slade, the Report was adopted as the Annual Report of the Association.

The scrutineers reported that the following were duly elected as Officers and Council for the ensuing year:—

PRESIDENT:

W. Whitaker, B.A., F.R.S.

VICE-PRESIDENTS:

R. S. Herries, M.A., Sec. G.S.	C. Davies Sherborn, F.G.S., F.Z.S.
H. W. Monckton, F.L.S., V.P.G.S.	J. J. H. Teall, M.A., F.R.S., Pres.G.S.

TREASURER:

R. Holland.

SECRETARIES:

Percy Emary, F.G.S.	Miss Mary C. Foley, B.Sc.

EDITOR:

C. Gilbert Cullis, D.Sc., F.G.S.

LIBRARIAN:

Henry Fleck, F.G.S.

TWELVE OTHER MEMBERS OF COUNCIL:

H. A. Allen, F.G.S.	John E. Piper, LL.B.
L. L. Belinfante, M.Sc., B. ès L.	A. E. Salter, B.Sc., F.G.S.
Rev. J. F. Blake, M.A., F.G.S.	W. P. D. Stebbing, F.G.S.
Dr. Edward Johnson.	Miss E. Whitley, B.Sc.
A. S. Kennard.	A. Smith Woodward, LL.D., F.L.S., F.G.S.
Frederick Meeson.	

A. C. Young, F.C.S.

The best thanks of the Association were then voted to the Officers and Members of Council retiring from office, to the Auditors, and to the Scrutineers.

The President then delivered the annual address, entitled "Twelve Years of London Geology."

On the motion of Rev. J. F. Blake, seconded by Mr. F. W. Rudler, it was unanimously resolved that the President's address be printed in extenso.

ORDINARY MEETING.

FRIDAY, FEBRUARY 8TH, 1901.

W. WHITAKER, B.A., F.R.S., President, in the Chair.

The following were elected members of the Association:—John Herbert Bowman, Sidney H. Reynolds, M.A., F.G.S., William Winterbotham, B.A.

There being no further business the meeting then terminated.

VISIT TO THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD.

SATURDAY, MARCH 2ND, 1901.

(*Report by* MARY C. FOLEY, B. SC., *Secretary for Excursions.*)

the kind invitation of Dr. Henry Woodward, F.R.S., F.G.S., per of the Department of Geology, a large party numbering veen 30 and 40 members assembled at the Natural History ;eum for the purpose of inspecting the recently arranged tile Gallery. As on former occasions, Dr. Woodward acted ıe director, and the members present passed a most enjoyable noon. Their attention was directed chiefly to the entirely ranged series of Plesiosauria and Ichthyosauria, which were ıerly displayed in ordinary wall-cases 10 feet in height, but now each separately framed and glazed, and placed flat upon south wall of the Gallery, commencing at about 4 feet from ground, to a height of 13 feet up. The slabs containing e imbedded "sea-lizards" vary much in size, the largest, *iosaurus cramptoni*, being 24 feet in length and 14 feet in ıdth; and the two large examples of *Ichthyosaurus platyodon* ıg about 22 feet in length by about 7 feet in breadth. enty-seven Plesiosauria and 113 Ichthyosauria are thus exhid upon the south wall of the Reptile Gallery. These numbers some idea of the extreme rarity of the long-necked Plesioria as compared with their short-necked contemporaries the thyosauria, which must certainly have been the dominant e in the Liassic period.

Two beautiful, and almost perfect, articulated skeletons of an ford Clay Plesiosaur, *Cryptoclidus oxoniensis*, from Fletton, r Peterborough, exhumed by A. N. Leeds, F.G.S., occupy two es in the centre of the Gallery. The larger of these is 13½ feet 4½ feet, the smaller 7 by 3 feet, and they give a better idea of anatomy of this reptile than any specimens ever seen before. ny beautiful and perfect paddles, collected by Mr. Leeds, e also inspected. Special attention was directed to the leges of *Brontosaurus*, a vegetable feeding Dinosaur, and to *saurus*, a carnivorous Dinosaur exhibited for the first time; to the wing-bones of *Pteranodon*, a flying lizard with wings isuring 18 feet across.

Dr. Smith Woodward, on behalf of Dr. Moreno, of the La ta Museum, exhibited the skull of *Miolania* from Patagonia, a iarkable extinct chelonian with horns on its skull. Another onging to the same genus had been already discovered in eensland, and one on Lord Howe Island, 700 miles off the

the one hand, he suggested a fault, or unconformable boundary, separating the Greywacké or Devonian rocks on the north from a more ancient group on the south; on the other, he expressed the opinion that the rocks on the south might be, from some cause or other, altered representatives of those on the north. The first alternative was ably advocated by Professor Bonney in 1874, when the altered region was claimed as Archæan on petrological grounds, and the dividing line taken as a fault.

Subsequently Mr. Somervail contributed the results of a series of field operations, which led him to regard the varieties of altered rocks on the south as representatives of unaltered rocks on the north. The controversy was carried on by Mr. Hunt and Miss Raisin. The object of the Director having been rather to enable the members of the Association to observe the facts, as far as possible in so short a time, and to form their own opinions, than to advocate any particular view, it is proposed to preface the Report by a brief description of the Devonian and altered areas embraced in the little map which accompanied the programme and is here reproduced.

The Middle Devonian limestones of Torquay and Brixham are replaced by volcanic rocks (the Ashprington series) at Totnes, and they are represented by slates with volcanic rocks from Totnes westward to the Yealmpton and Plymouth limestones. These volcanic rocks, being a continuation in part of the Ashprington series, are marked I on the map.

On the south of, and beneath the volcanic rocks, as in the limestone areas, Eifelian slates are always present (marked 1). They rest on Lower Devonian rocks, which consist of grits and sandstones—the Staddon grits, homotaxial with the Upper Coblenzian of the Continent—and are denoted by a 2 on the map.

The Staddon grits (Warberry beds) are succeeded by grey slates with hard grits in very variable proportion. Decomposed calcareous matter occurs in them in lenticles containing crushed fossil-casts in places; there are also impersistent horizons of igneous rocks, probably of volcanic origin. These beds are the Meadfoot series (3 on the map). Their fauna places them in the upper part at least, in the Lower Coblenzian of the Continent; but in the Torquay promontory, in which no lower rocks than the Meadfoot beds occur, and also near Paignton, *Rhynchonella pengellyana*, *Spirifer primævus*, and one or two other forms which occur in the Looe beds and in Continental Lower Devonian rocks below the Lower Coblenzian, have at different times been identified. Hence it is uncertain whether the Looe beds may not be included in the Meadfoot series.

The next series (4 on the map) is the Dartmouth slates. These beds, with frequent fault-boundaries on the north, have been traced from Scabbicombe Head, in the Kingswear promontory in Devon, to Polperro in Cornwall. They are the

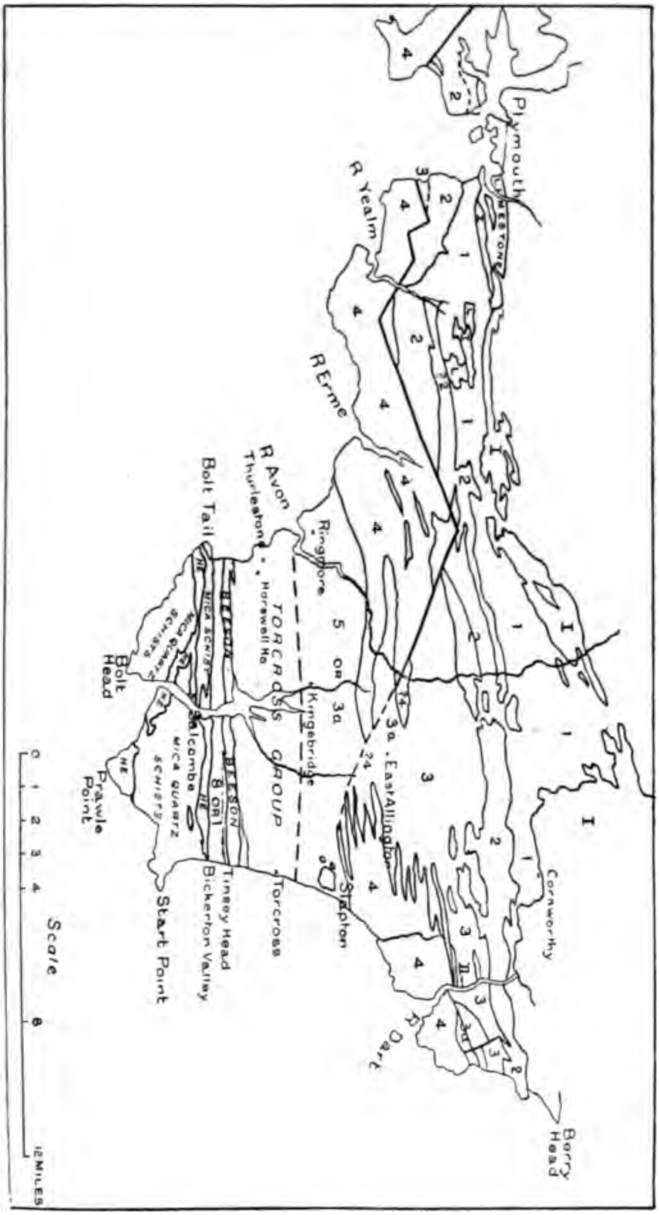


FIG. 3. MAP SHOWING THE GEOLOGY OF THE SOUTHERNMOST PART OF DEVON. By W. A. E. USSHER, F.G.S.

I. Ashprington Volcanic Series (Middle Devonian).

5 or 3a Ringmore Group.

variegated slates in which *Pteraspis* scales have been found. Where unfaulted, the dark slates of the Meadfoot group seem to pass down into or overlie the Dartmouth slates. In the Kingsbridge area, however, this group seems to attenuate through being faulted or folded out. The evidence is inconclusive as to the position or presence of faults near East Allington, where the attenuation or partial disappearance of the group takes place.

To the south of the Dartmouth slates we encounter reddish and grey slates, and shales with fossiliferous matter, and occasionally gritty beds. This series extends from Slapton on the east, through Kingsbridge, Churchstow, and Ringmore, to Challaborough and Ayrmer Cove on the west coast. In it *Spirifer primævus* has been found, and it may with very little hesitation be regarded as representative of the fossiliferous beds of Looe, in part. This group is termed the Ringmore or Ringmore-Coltscombe group, from fossiliferous localities. On the map it is numbered 5 or 3a. This alternative numbering expresses the problem of the area—viz., the Dartmouth slates (4) overlie the Ringmore group (5), and are faulted out near East Allington; or, the Dartmouth slates (4) are the lowest Devonian rocks in S. Devon, and, whether faulted or not, occur in a complex anticline, the lower part of the Meadfoot series on the north being repeated in (3a) the Ringmore group on the south, and the higher part represented by the Torcross group.

The Torcross group consists mainly of grey slates, with grit or fine siliceous lenticles and bands, and also contains impersistent bands of igneous rock, which appear to be contemporaneous. This group occupies a broad belt of country, extending from the Torcross to the Thurlestone coast. It is named Torcross group on the map (? 3).

The next group is characterised by quartzose grits, which are not exposed on either coast, but occur in a series of patches from Beeson westward, in slates with hard grits irregularly interbedded, shown near Beesands on the east coast and at Beacon and Woolman's Points on the west. At Tinsey Head the slates are interlaminated and interbedded with siliceous materials, and contain films of crinoidal limestone. This group is named the Beeson grits, and numbered 7, 3a, or 2, "Beeson" on the map. The latter number indicates the possibility of these beds representing the Warberry group, or its base in synclinal structure: 3a provides for the connection of this group as an anticlinal with part of the Ringmore group.

To the south of the Beeson grits a belt of slates, containing occasional traces of limestone and *Zaphrentidæ* forms the northern border of the highly-altered rock. This band is numbered 8 on the supposition of a continuous descending series, 1 to admit of the possibility of a continuously ascending series from the Dartmouth slates southward, and 3 on the supposition that it is a part of the Torcross series repeated on the south of an anticlinal or synclinal of the Beeson grits.

The altered rocks form two distinct series. The lower consists of mica and quartz schists of sedimentary origin, the higher of an altered basic group, mainly composed of hornblende-epidote schists. Although the latter is generally of a pronounced green colour, both on its borders and in its mass, it is locally oxidised, and here and there assumes brown and buff tints. The terms, green schists and hornblende-epidote schists, are here used indiscriminately.

The altered igneous group is in contact with the Devonian on the west of the Salcombe Estuary, where it forms two bands, the southernmost constituting Prawle Point, etc. These are separated by an anticline of mica schists which dies out on the west of the estuary, where these bands coalesce.

Continuing westward to Bolt Tail and Inner Hope, the green schists separate the mica-quartz schists of the Bolt Head district from mica-quartz schists in contact with the Devonian slate band on the north.

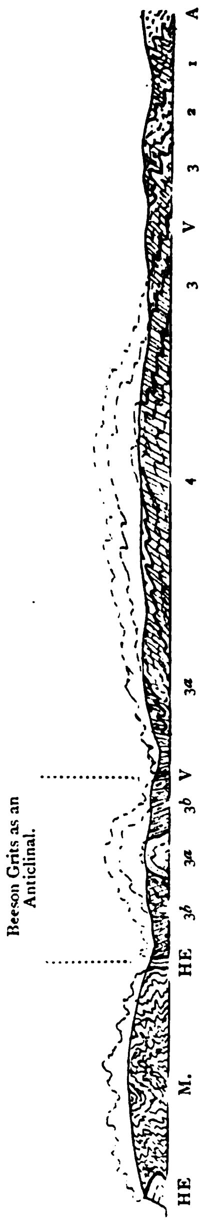
The junction between the Devonian and altered rocks is almost invariably marked by the presence of rusty-brown decomposed rocks, generally containing hard carbonates. These rocks often intervene for a distance of several chains. The contrast between the comparatively unaltered Devonian slates and the highly altered rocks, on either side of this neutral zone, is everywhere strongly marked; nor were any evidences of progressive metamorphism detected in the Devonian rocks approaching the boundary.

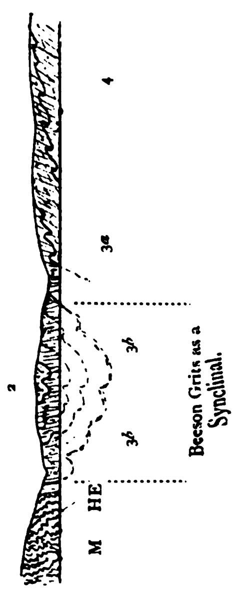
Anyone can construct for himself the section which exhibits the Dartmouth slates as a member of a descending sequence, and it will be seen that on such a section it is difficult, if not impossible, to conceive that the altered rocks can be altered Devonian.

The alternative view can easily be shown by a section in which the Dartmouth slates as an anticline throw off an ascending sequence toward the south, causing the southernmost slate band to correspond to the Eifelian slates. This view would, of course, bring the hornblende-epidote schists into direct relation to the Ashprington series, a coincidence hard to explain except on the theory that the one is an altered representative of the other.

In both these views the Beeson grit group is taken as a persistent horizon, not as a folded repetition (which is suggested by the impersistence of the characteristic grits). The variation made in either of these sections by the indication of the Beeson grit group as an anticlinal or synclinal would cause the hornblende-epidote schists on the south of it to occupy a corresponding position to the Torcross volcanic bands on the north; but on this supposition the mica-quartz schists could only be regarded as

FIG. 4.—DIAGRAM SHOWING THE DARTMOUTH SLATES AS AN ANTICLINAL.





INDEX.

A. Ashprington Volcanic Series.
1. Eifelian Slates.
2. Warberry Grits.
3. Meadfoot Beds (Volcanics, V).
3a. Ringmore Beds.
3b. Torcross Beds (Volcanics, V).
HE. Hornblende-Epidote Schists.
M. Mica-Quartz Schists.

altered Devonian, on the assumption of an anticlinal of Dartmouth slates. The section would then present the relations shown in the accompanying diagram.

As the Devonian structure is capable of more than one interpretation, no evidence can be deduced from it in support of either theory as to the age of the altered rocks.

In favour of the metamorphic origin of the altered rocks, the following facts are to be taken into account:

1. Entire absence (as it seems to me) of any appearance of progressive metamorphism in the Devonian rocks, approaching the boundary.

2. Abruptness of the change in character displayed on either side of the boundary, although, as Prof. Bonney has pointed out, local resemblances occur on either side.

3. The absence of any volcanic development comparable in extent to the hornblende-epidote schists in the Devonian area nearer than the Ashprington Middle Devonian Volcanic series.

4. The much greater intensity in the crumpling to which the mica-quartz schists have been subjected than is apparent in the Devonian rocks.

In support of the contention that the altered rocks are nothing more than highly metamorphosed representatives of rocks in the Devonian area, the following points are worthy of consideration:

1. The mica-quartz schists in character and association exhibit an original sedimentary origin similar to that displayed by the Devonian rocks, denoting similar conditions of deposition. The hornblende-epidote schists as an altered basic group may be compared to the Middle Devonian Volcanic development (the Ashprington series) and to the much feebler evidences of vulcanicity in the Lower Devonian, Meadfoot beds and Torcross group.

2. The appearance of a passage of the Devonian into the junction brown rocks in some sections, and of the mica and hornblende-epidote schists passing into them in others. The difficulty in defining any absolute boundary in such sections as Southpool Creek and Hope.

3. The correspondences in the general strike on either side of the boundary is very noticeable. The plications are similar in kind, though very different in intensity. This is well shown by the gnarling of the mica schists compared with the gnarling and puckering shown in the Devonian sections. This last point is not, however, conclusive in itself, as the movements affecting the Devonian rocks might have followed the same lines as prior movements affecting a more ancient series of rocks before the deposition of the Devonian.

Report.

On Thursday evening, April 4th, the members, who numbered 58, arrived at Kingsbridge; the atmospheric conditions were uninviting.

TORCROSS AND START COAST.

On *Friday* morning the members left Kingsbridge for Torcross in brakes at 9.30. On arrival at the Torcross Hotel they were met by Mr. Hunt, who had, with kindly forethought, printed in advance notes on the objects of interest on which he would have spoken during the excursion, had the weather been favourable and his health permitted. The points of interest as regards the beach, along which the party walked from Torcross to Hall Sands, are summed up in the following passage:

> * TORCROSS.—The rounded shingle in Start Bay is peculiar and interesting. It is limited by Start Point on the west and by the River Dart on the east.
>
> Flint shingle is, or was, abundant at Hall Sands (where dredging on a large scale has been going on for years), but flint sand is almost absent at the N.E. end of Slapton Sands. Its derivation is uncertain.
>
> The immense amount of shingle, damming back, as it does, the land-water of Slapton Ley, indicates an excess of supply over wear and tear in times past, rather than any change of level. On rare occasions the shingle has been breached and the lake invaded by the sea.
>
> In the shingle of Start Bay the process of the rounding of quartz by wave action can be traced from the quartz vein through pebbles to coarse sand, and in the skerries shoal off shore it can be further traced to fine sand.

At the commencement of the walk along the base of the cliffs attention was called to the bands of grit and of igneous rocks in the slates, and to the synclinal curve figured by Professor Bonney, where the bedding is shown by thin hard bands, broken and tilted along the cleavage planes, and igneous rock is visible above the slates. Farther on, a grit bed cleaved in thin, nearly horizontal layers, was pointed out in the slates.

Attention was attracted to a fine example of the Torcross igneous rocks, containing large irregular plates of leucoxene. This rock is shown in junction with the slates on either side in a projection from the cliffs. It is probably a much modified contemporaneous diabase. The igneous rocks, as pointed out by Mr. Hunt, are occasionally porphyritic in this part of the coast.

Near this were seen the irregularly gnarled indications of bedding which are sometimes marked by harder seams, some-

* [The indented paragraphs in this report are taken from the printed notes which were supplied to each member by Mr. Hunt.—Ed.]

times by quartz veins parallel with them, and sometimes by brownish banding. Mr. Hunt drew attention to the presence of crinoids and small zaphrentid corals in the slates. The party then visited Sunnyvale quarry under conditions that did not justify its name. The slates had been largely quarried here for roofing materials, and although abandoned for many years the weathered tool-marks are clearly seen. Beyond this the modern beach dams back the drainage in a small lake called Widdecombe Ley. No cliff section is visible where the characteristic grits of the Beeson group reach the coast; their position was indicated. Just beyond Beesands village the hard grit beds in the slates which have been included in this group display many contortions, besides faults and thrusts. Farther on, near Tinsey Head, notice was called to films of crinoidal limestone with siliceous interlaminations. The interlaminated argillaceous and siliceous materials were seen to be beautifully puckered in the vicinity of faults. These beds constitute Tinsey Head, they are included in the Beeson group, and were afterwards seen on the west coast at Beacon and Woolman's Points near Hope.

Mr. Hunt contributes the following notes:

> A slice of the Beesands grit (4 chains south of Beesands), contains microscopic tourmaline, of which one minute crystal has been dislocated and recemented by quartz; thus indicating both a severe squeeze and the incipient formation of secondary minerals in the grits.
>
> In a slice of fine grit north of Tinsey Head, a minute grain of tourmaline is slightly, albeit distinctly, affected by solution, with indications of the re-crystallisation of secondary tourmaline.

From Tinsey Head the cliffs were found to consist mainly of grey slates with occasional traces of limestone. Many differences in cleavage-dip were observed, and cracks, faults, and thrusts were noticed in places At about 5 chains from the termination of the cliff, at the mouth of the Bickerton Valley, the members were introduced to the brown rocks, which obscure the junction with the altered groups. These were seen to be partly associated with grey slates, and are believed to be in part of volcanic origin. They are faulted in several places in the short exposure of about 100 yards. Hard carbonates occur in them.

As the hornblende-epidote schists are concealed, in their extension to the coast from the village of Bickerton, by the alluvium of the Bickerton Valley, a détour was made to a quarry in them on the northern margin of the alluvium. This quarry was first recognised by Mr. Somervail. Although largely overgrown the green schists were observed *in situ*. This locality and the village of Bickerton on the south are thus referred to by Mr. Hunt:

BICKERTON VALLEY.—Quarry in green rocks on the north side. In my two slices from this quarry water-clear granules of felspar are scattered evenly throughout the green matrix.

BICKERTON.—A slice from this locality displays the felspars arranged in roughly parallel bands (microscopic), but still as granules.

From the Bickerton Valley to the Hall Sands village the cliffs composed of mica schists and quartz schists were observed. Attention was drawn to the similarity in their association to that displayed by the argillaceous and siliceous interbandings in the Devonian section. A band of the green schists was also pointed out, and two or three thinner seams. The great contortion and almost universal gnarling displayed by the mica-quartz schists was also noted, as well as faults, cracks, and thrusts.

A mass of consolidated "head" mixed with old beach material forming the roof of a cavern was also pointed out near Hall Sands village.

From this village the party proceeded by the cliff path to the Start lighthouse, observing on the way the craggy arrête of quartz schists which form the backbone of the promontory. With few exceptions the members proceeded to the lighthouse, where, notwithstanding their number and unexpected advent, they were regaled with a substantial tea. Meanwhile, a small party visited Peartree Point, whence a fine view of the Prawle and of the intervening raised beach platform was obtained. At Peartree Point their attention was drawn to numerous veins of pegmatite (quartz albite) in the mica-quartz schists. On the way back to the Start, the Directors showed the position of a small mass of hornblende-epidote schist in an inverted synclinal curve in the mica schists of Spirit of the Ocean Cove (near Foxhole Cove). Specimens were obtained by an adventurous member, and Mr. Hunt produced a microscopic slide. He remarks as follows:

SPIRIT OF THE OCEAN COVE.—The water-clear felspar has lost its isolated granular character. It is distributed in roughly parallel streaks.

Mr. Harker describes a slice as "a mass of minerals newly crystallised *in situ* and having the fresh appearance so characteristic of the crystalline schists. Original structures are completely obliterated": this seems to be the case throughout the Green rocks, without exception. The minerals described by Mr. Harker are compact and fibrous amphibole, felspar (albite or andesine), ripidolite, epidote, and zoisite.

> PINK FELSPATHIC VEINS.—These are not uncommon in the mica schists in the neighbourhood of the Green rocks. They may afford a clue to the process of metamorphism.

The quartz schists are thus alluded to:—

> SOUTH OF START FARM.—In a slice of one of the quartz schist bands, two minute crystals of tourmaline occur; one a longitudinal, the other a basal section. In both cases there is a re-crystallisation of the tourmaline, and in both cases also a slight shearing movement has detached and removed to a short distance portions of the newer growth.
>
> At this spot only has the quartz schist revealed any traces of its original sedimentary components in grains of quartz sand and of tourmaline.
>
> The quartz schist bands containing tourmaline have much resemblance to the grit bands in the slates, both in their relation to the mica schists and in their fineness of grain. If there is no connection between the two sets of rocks, the conditions of sedimentation at the deposition of the schists must have been exactly repeated in Devonian times.

From the Start to Torcross the prevalent dip of the schistosity is toward the north, although frequently vertical, southerly dips are exceptional. As regards the numerous examples of bed-veins and gash-veins of quartz met with during the excursion, Mr. Hunt remarks:—

> QUARTZ VEINS.—These are probably of two ages, before and after the metamorphism of the district. Certain silky-looking quartzes may be the more ancient. The fluid inclusions vary in character. This inquiry awaits an enthusiast.

The brakes met the party within a mile of the Start Lighthouse, whence they were driven back to Kingsbridge.

SOUTHPOOL AND THE PRAWLE.

On *Saturday, April 6th*, the party started early and drove to Southpool, where a halt was made for two hours, whilst they visited Scoble Quarry on the west side of the creek. The continuation of the Beeson grit group was crossed on the hill above Southpool, and the creek section commences with grey slates with intercalated beds of hard grit, corresponding to the coast section south of Beesands village. The Director pointed out the partial replacement of these hard fine grits by quartz. For about 56 chains the low cliff banks consist of Devonian rocks, with planes of schistosity inclining northward; the party then encountered decomposed brown rocks, which form the section for 3 or

4 chains. Faults and thrusts were noticed both in the Devonian and in the brown rocks. Conspicuous amongst the latter are some even beds of dark brown, tough, friable rock with drusy cavities, strongly suggestive of the decomposed residues of limestones impregnated with iron carbonate. In parts the brown rocks were seen to resemble those at the mouth of the Bickerton Valley. In one place they exhibit an anticlinal structure, and seem to pass into the green schists, which are here interbanded and interstratified with mica schist through plication. In Scoble Quarry good specimens of the hornblende-epidote schists were obtained. The President drew attention to the decomposition of the green rocks from the surface downward, which was here accompanied by brown discoloration.

On rejoining the brakes at Southpool the party was driven to the village of East Prawle. On descending the steep slope to the coast, by the path east from the coastguard station, they crossed a tract of flattish ground—marking the débris, or "Head" shed on the old beach plane during the elevation of the beaches. This accumulation of earth, studded with fragments from the higher ground, was inspected in the cliff. The party then walked for about a mile along the rock reefs at the foot of the cliff. The Director pointed out alternations of masses of mica schist and of hornblende-epidote schists, produced by the plicated repetition of the junction beds of each group, and often accompanied by faults or thrusts. These alternations were encountered at irregular intervals from the point where the party descended to the beach reefs to Landing Cove (beyond Langerstone Point) where the green schists finally prevail.

At the foot of the cliff, some chains from the spot where the party descended, and in the opposite direction to that taken, are two boulders, probably erratics, "described [as Mr. Hunt informs us] by Mr. Harker in Trans. Devon. Assoc., 1896, pp. 531, 532. A Granite Gneiss and Quartz Diorite." Occasional signs of old beach material were seen to be incorporated in the base of the cliff of Head. From Landing Cove the party climbed the steep slope to the Prawle Signal Station, and from thence followed the coastguard path to Elender and Macely Cove. On the way many fine crag exposures of the hornblende-epidote schists were noticed. The Director drew attention to the even planes which give a deceptive appearance of bedding to this group. The interplanal movements affecting the true bedding are in many cases distinctly shown in intensely contorted bands, crossing the horizontal planes vertically. Time did not permit of a visit to Venericks Cove, where a pinnacle of Head rests on the old Beach reefs at about 60 yards from the cliff At Elender Cove the party mustered and walked back to East Prawle, quitting the green schists at about a quarter of a mile north of the Cove. Had the members been able to extend the journey along the cliffs, th[illegible] would have encountered repetitions, through synclinal plication, of masses of the Prawle green schists on Rickham Sands. It is thus that the southern band of hornblende-epidote schists gradually strikes northward to its coalescence with the northern band on the west of the Salcombe Estuary. Mr. Hunt refers to a specimen from this coast as follows :—

> The water-clear granules in a slice of a green rock from Rickham Sands were carefully tested by Mr. Teall. Twelve granules taken at random proved to be felspar. In the Rep. Geol. Survey for 1891 the green rocks are described as consisting of hornblende, albite, and epidote. So we may take these water-clear granules and streaks to be albite.

After tea at East Prawle, the members drove back to Kingsbridge.

On April 7th many of the party visited Salcombe, and walked along the coast-road to the Bolt Head. The gnarled and contorted mica-quartz schists are here split up irregularly by great contortion-planes, which determine, according to their inclination, the rugged outlines of the Bolt Head Cliffs.

THURLESTONE COAST, HOPE, AND BOLT TAIL.

On *Monday, April 8th*, the members drove to Horswell House Quarry, south of Thurlestone. The quarry exhibits a rock resembling New Red breccia of more or less local derivation upon andesite. Opposite to this the andesite is in irregular, apparently intrusive, association with Devonian slates. In the central face of the quarry quartz-porphyry is associated with the andesite. The quarry faces are largely concealed by talus; the want of correspondence in the opposite sides may be due to a fault throwing down New Red on the north. The igneous rocks are much decomposed. Whether they form part of a pipe of a Permian volcano, in activity before or subsequent to the deposition of the New Red outliers of Thurlestone, or whether the intrusive rock ever reached the surface, there is not sufficient evidence to say; but in either case the rocks would appear to be connected with the Permian eruptions so well evidenced in the Exeter, Broadclist, and Crediton districts in the east, and with the felsites of Cawsand and Withno on the west.

From Horswell House the party drove through a storm of hail and rain to Thurlestone Sands. These sands partially dam back the drainage of the streams which here reach the coast. At the north end of the sands the cliff commences with New Red breccia, which is seen at a few chains further on resting irregularly on the upturned edges of the Devonian slates. The Director pointed out the successive overlap of the beds of breccia on the margin of the older rocks as they rise to the summit of the

Tuesday, April 9th.—The party drove to Balls Cross, near Lower Batson. After crossing some fields, over which fragments of the Beeson grits were scattered, they descended to the coast at Iltoncastle Plantation, and thence (following the foreshore as far as possible, though at times compelled to scramble through undergrowth and brambles) they passed from the Devonian rocks to the altered rocks at 25 chains north of Ilberstow Point. The Director pointed out the same plicated association of beds of grit in the slates as had been seen near Southpool and elsewhere on previous days. The slates near Tosnos Point contain, as in the Tinsey Head coast, traces of crinoidal limestone. The doubtful brown rocks were encountered in plication with slates and mica schists on the south of a gentle slope down to the beach. Between this and Ilberstow Point, which is composed of varieties of the hornblende-epidote schists with bedding often beautifully contorted between their planes, numerous alternations were seen of brown and green rocks with mica schists. On rounding the Point, these plicated alternations were again investigated on the shores of Batson Creek. The Director showed that the rapid alternations on this coast were due to the troughing out of the northern zone of hornblende-epidote schists, which, on crossing the main creek, thus shifts its position to the southward, finally coalescing with the southern (or Prawle) band, west of Salcombe.

Meeting the conveyances at West Batsonhill Cross, those of the party who did not visit Salcombe returned to Kingsbridge, where they arrived at 1 o'clock, and, after lunch, proceeded by the 2.30 train to their several destinations.

On Tuesday evening, after dinner, votes of thanks were accorded to the Directors and Excursion Secretary, and general satisfaction for the catering and hotel arrangements was expressed. A vote of thanks was also passed to the Kingsbridge Institute for throwing open their reading room to the Members of the Association during their stay at Kingsbridge.

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EXCURSION TO THE EAST LONDON WATERWORKS, TOTTENHAM.

SATURDAY, APRIL 27TH, 1901.

Director: THE PRESIDENT (W. WHITAKER, B.A., F.R.S., F.G.S.).

Excursion Secretary: H. W. MONCKTON, F.G.S.

(*Report by* H. W. MONCKTON.)

THE party left Liverpool Street Station by the 2.47 p.m. train, arriving at Tottenham Hale at 3.1. They at once made their way to the entrance to the works in the Woodford Road, where, through the kindness of Mr. W. B. Bryan, the engineer, and Messrs. S. Pearson and Son, a special engine and carriages had been provided. Before starting, the President described the extent of the works. A break was made in the journey, in order to enable the members to see the relics found during the course of the excavations. These were not very numerous, offering a marked contrast to what had been found in former excavations; but this without doubt arises from the use of the "steam digger, or navvy," which the members had an opportunity of seeing at work; in fact, practically everything found has been found during hand digging. The most important find is a fine example of a "dug out," made from the trunk of a large oak. This was found near a stream, which was diverted during the work. Though usually considered to be of pre-Roman age, yet it is worthy of note that at the same level, and only a few feet away, the neck and upper part of a Roman Amphora was also discovered. The other relics comprised a Saxon spear head, two wooden implements, probably pile-drivers or mallets, two human skulls, an antler of red deer, bones of *Bos longifrons*, horse and sheep, fragments of a Viking ship (the bulk of which had been taken away piecemeal by the inhabitants of the neighbourhood), with other objects of Roman, mediæval and modern age. An article in iron, which had puzzled the experts, was clearly shown to be a scraper. The party then partook of tea and light refreshment, which had been most kindly provided by Mr. C. W. Sharrock.

On entraining the party were conveyed to Chingford Mills, the intake of the works, and thence to the most interesting sections, where the members alighted. The sections seen varied greatly, a characteristic of all alluvial deposits, but the sequence was, broadly speaking, about 10 feet of peaty alluvium resting on gravel. In places the alluvium was seen to contain lenticular patches of shell marl, whilst in one place the gravel itself contained similar shells, thus clearly proving its Holocene age. Underlying the blackish-grey gravel is another bed of red gravel, seen in a few trial holes, and probably of Pleistocene age. Many of the members availed themselves of the opportunity to collect from the shell marl, whilst the bones of horse, sheep, red deer, pig, *Bos longifrons*, and dog or wolf, were also obtained. In former excavations the remains of elk, bison, *Bos primigenius*, fox, goat, beaver, roedeer, fallow deer, reindeer, and great Irish deer, have also been found, besides a single bone of the sea eagle (*Holiœtus albiceltus*). No less than fifty-two species of mollusca have been described from these beds, of which the most interesting is *Acanthinula* (*Helix*) *lamellata*, a species not known living south of Staffordshire. The fish and the smaller vertebrates are practically unknown. Numerous photographs were taken of the sections, and the party then walked to the Ferryboat Inn, where an excellent tea was provided.

After tea the President moved that a cordial vote of thanks be given to Mr. W. B. Bryan and Mr. Ashley, of the East London Waterworks, and to Mr. C. W. Sharrock and Mr. Traill, for their great kindness during the excursion; this was carried by acclamation, and the party then returned to town.

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EXCURSION TO GROVE PARK AND CHISELHURST.

SATURDAY, APRIL 27TH, 1901.

Director: T. V. HOLMES, F.G.S.

Excursion Secretary: H. W. MONCKTON, F.G.S.

(*Report by* THE DIRECTOR.)

THE object of this excursion, as in the case of that on July 28th, 1900, was to see the sections displayed during the widening of the S.E.R. main line.

The sections in the cutting north of the tunnel were, on the whole, in as good a condition as they had been when last year's excursion took place, and the description of them then given will suffice for the more recent visit. But this year we were fortunate enough to have with us Mr. C. W. Osman, who, in addition to being a member of the Geologists' Association, is an engineer engaged on these railway-widening operations. Through his kind aid we were enabled to enter the new tunnel now being made parallel with, but a few yards westward of, the old one, and to note the nature of the rocks penetrated up to the date of our visit. The new tunnel, we learned, was then between three and four hundred yards long, and we proceeded from its more northerly mouth as far as the progress of the works permitted. The top of the tunnel, towards that end, is in London Clay, but the greater part of it there, and the whole towards the southern mouth, is in the sands and pebble beds of the underlying Oldhaven or Blackheath series. In the tunnel we noted, among the sands, many hard masses of pebbles cemented together, the cement being calcareous, and derived from the decomposition of shells, which were abundant but not easy to obtain in a perfect state.

Emerging from the northern mouth of the tunnel, the party proceeded through the wood above, along a path marking the tunnel's course beneath the surface, to the Chiselhurst end. For about three-fifths of the way the route was over a hill of London Clay having a slight irregular capping of pebbles. Then, in a hollow, a shaft showed sand crowded with *Pectunculus* and other shells, and containing blocks of cemented pebbles like those seen in the tunnel, and thence to, and around, the southern mouth of the tunnel the Blackheath Pebble Beds formed the surface, as shown in the section below.

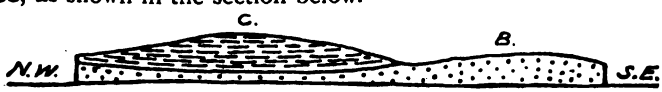

FIG. 5.—SECTION ALONG THE LINE OF THE TUNNEL BETWEEN GROVE PARK AND CHISELHURST RAILWAY STATIONS. LENGTH ABOUT 950 YARDS.

B.—Blackheath Pebble Beds.
C.—London Clay.

From the more southerly end of the tunnel the members made their way to the Bickley Hotel, near Chiselhurst Railway Station, to partake of tea. On their way they noted that the sections which lately showed Chalk and Thanet Sand, close to the western corner of Camden Park, are now hidden by newly erected buildings. A few yards from the hotel, Mr. Osman took them to a spot where material, consisting largely of the shell-beds of the Woolwich Series, had been brought from near Orpington to widen the railway embankment. Most of the party returned to London from Chiselhurst by the 6.58 train.

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EXCURSION TO SWANSCOMBE.

SATURDAY, MAY 4TH, 1901.

Directors: A. S. KENNARD and A. E. SALTER, B.SC., F.G.S

Excursion Secretary: A. C. YOUNG, F.C.S.

(*Report by* THE DIRECTORS.)

THE members assembled at Cannon Street (S.E.R.) and travelled by the 2.38 train, arriving at Greenhithe Station at 3.30 p.m. After passing through the village to the shore, where a not very successful search was made for fossils derived from the Chalk, they walked towards Swanscombe, Mr. H. Stopes pointing out Ingress Abbey, built mainly from the stones of old London Bridge, on the site of a farm belonging to Dartford Priory. On reaching the London Road a halt was made at Cliff House, where refreshments had been most kindly prepared for the party by Mr. Hoyle. After passing a most cordial vote of thanks to Mr. and Mrs. Hoyle for their kindness, the members proceeded to the Milton Street pit. This pit is worked for chalk for cement, and the overlying gravel is extensively dug. The sections seen showed about 14 feet of gravel resting upon the Chalk, with sometimes an intervening patch of Thanet Sand. Thousands of Palæolithic flint instruments have been obtained here, and their abundance was well shown by the large number which the members of the party obtained from the workmen. The Directors pointed out that this gravel is a part of the widespread sheet commonly known as the high terrace gravel of the Thames Valley, and that it was from a similar bed at Galley Hill that Mr. R. Elliot obtained the human skull and limb-bones, which are the only human bones known from this deposit. The occurrence of northern material, such as various kinds of quartzites, vein quartz, &c., was also emphasised.

Another section in the same gravel was exposed opposite the "Ingress Arms." Here, however, in contradistinction to what had been seen at Milton Street, the deposit was found to contain many mollusca and a few bones. The shells were extremely abundant, one form, *Neritina fluviatilis*, hitherto unknown from the Pleistocene of this country, still retaining its coloration. *Unio littoralis* and *U. tumidus* were common, both valves often being united and the ligament preserved. Most of the members availed themselves of the opportunity of collecting from this pit, since, as the Directors pointed out, it would not long be available for that purpose.

The party then returned to Greenhithe, where tea was provided, and, after votes of thanks had been accorded to the Directors and Mr. Stopes, returned to town by the 7.20 train.

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EXCURSION TO LEIGHTON BUZZARD, WING, AND STEWKLEY.

SATURDAY, MAY 11TH, 1901.

Director: A. M. DAVIES, B.Sc., F.G.S.

Excursion Secretary: A. C. YOUNG, F.C.S.

(*Report by* THE DIRECTOR.)

OWING to the inconvenient train service it was half past noon before Leighton Buzzard was reached. The party (twelve in number) started along the road to the north-west, which rising soon to above the 400 foot contour brought them to a point where a fine view was had over the Ousel valley, the great plain of Oxford Clay and the Woburn Sand-hills. Passing through Soulbury village, a halt was made for the examination of a fine boulder of limestone (probably Carboniferous), roughly measured as $4\frac{1}{2}$ feet by 3 by $2\frac{1}{2}$. At Stewkley the party was hospitably received by the vicar, the Rev. R. Bruce Dixon. Under his guidance the Church was visited—a rare example of a late Norman church almost untouched by later times.

A walk of a mile through the long village brought the party to two brickfields in the Kimeridge Clay. In the more northern one (Mr. Hedges') the shaley clay was seen, showing a gentle anticline and stained bright red and brown along one line where ferruginous water flowed out from a thin seam of sand. It was overlaid by unstratified clay, to which no one ventured to assign a name or age. The shaley clay, black when damp but drying to a light grey, almost white, was full of fossils, but they were for the most part too fragmentary or fragile to be worth taking. On previous occasions the Director had noted here abundant specimens of *Aptychus latus*, also Ammonites of the *biplex* and *cordatus* groups (mostly undersized), *Protocardia*, *Exogyra virgula*, *Lingu* *Discina* and fish-scales. Traces of most of these were seen, and vertebra of *Ichthyosaurus* was picked up.

In the second brickfield (Mr. Bliss's) the same clay was four but here attention was chiefly attracted by the large septar some of them over 3 feet across and 2 feet thick. Their ou surface showed excellent cone-in-cone structure, and interna were large cracks lined by nail-head crystals of calcite.

The path was next taken to the Warren, where the m northerly exposure in England of typical Portland beds w discovered many years ago by Fitton. The only part of t sequence shown very clearly was the 7 feet of typical greeni yellow Portland Sand. The upper bed of limestone was seen an old face, and many blocks of both this and the lower stc were available for fossil-collecting, and yielded the usual casts *Trigonia*, *Cardium*, etc., while the porch of the house was seen be paved with the characteristic gigantic Ammonites. A hunt v made for traces of Purbeck beds, and some passable clay a peculiar sandy limestone were found.

The party drove next to Littleworth, near Wing, where brickfield revealed a most interesting section. In the up diggings there was exposed about 15 feet of Drift, chiefly gra but with intercalations of sand, and at one place of a boulc clay. The materials of the gravel were chiefly flint, but c measure sandstone was also found. In the lower diggings Gault was exposed—a light bluish clay with small brownish-wh phosphatic nodules, and under this a remarkable basement b in which black phosphatic nodules (one at least a cast o Lamellibranch) were imbedded in a bright bluish-green mater while here and there masses of red oxide of iron occurr Immediately below this came black shaley Kimeridge Cl from which the workmen had collected fossils—chiefly reptili bones, but including also a large clavellate *Trigonia*, and a stc Belemnite evidently Jurassic. In the Gault itself, *B. minimus* w found.

The entire absence of Lower Greensand in this section was the more interesting, as little more than a mile and a half awa at Southcott Mill, the party were able to see the first exposure that formation, which attains such a thickness at Leighton ar Woburn. Some doubt was expressed as to the correctness identification of this exposure as real Lower Greensand, as was thought to be too pebbly, and some of the pebbles had suspicious resemblance to flint. Further examination, however, pu these doubts at rest, and then the return journey to Leighto was quickly completed.

After a hearty tea at the "Albion Hotel" the party proceede under the guidance of Mr. Faulkner, the manager, to Messrs Arnold and Son's sandpits at Grovebury. The enormous exten these excavations caused general surprise, and it was felt tnat ey deserved longer time for study and the assistance of a photo- :apher. The sand is beautifully false-bedded, and overlaid in laces by valley-alluvium, elsewhere by gravel, and in several of he pits by boulder-clay. In one case boulder-clay appeared to e intercalated in the gravel, as at Littleworth. The great ariation in the thickness of these superficial deposits adds to the ifficulty of working. Much of the sand goes to London and sewhere for building purposes, but certain qualities are sent ng distances for potting plants. In the fading light only a sty examination of the many large pits was possible, and the urn to London was made by the 8.35 train.

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EXCURSION TO GRAYS THURROCK.

SATURDAY, MAY 18TH.

Directors: MARTIN A. C. HINTON AND A. S. KENNARD.

Excursion Secretary: A. C. YOUNG, F.C.S.

(*Report by* MARTIN A. C. HINTON.)

s was an excursion arranged to give the members of the ciation an opportunity of examining some of the sections and es described by the Directors in their paper before the Field Club, the first part of which has just been pub- . The party of twenty-two left Fenchurch Street by the rain. On arrival at Grays the members proceeded to a ection off the Orsett Road, which showed the deposits of ddle Terrace. The lower part consisted of a series of ely-laminated clays, containing few fossils, but from which ectors have obtained bones of *Cervus Bos*, &c. The ortion of the section was occupied by a lenticular mass with thin seams of gravel. The sand was arranged in an ng series of thin bands cemented by oxide of iron, and coherent laminæ. The latter were crowded with land water shells, and contained also many bones and teeth ertebrates. Above this series was a thick mass of stiff ochreous loam. Mr. Kennard explained the section to the party, and some time was spent in collecting fossils. The Directors have obtained many new palæontological records from the fossiliferous portion, including a fine series of fishes, the determination of which is due to Mr. E. T. Newton, F.R.S. The other vertebrates have been determined by Mr. Hinton, while Mr. Kennard is responsible for the mollusca. The Directors are greatly indebted to Messrs. J. P. Johnson and G. White for the kind way in which they communicated the specimens in their collections.

The following is the list of Vertebrata new to the Grays deposits, and those marked with an asterisk are new to the Pleistocene of the Thames Valley :

MAMMALIA	**Microtus agrestis.*
	* ,, *glareolus.*
	,, *gregalis.*
	* ,, *nivalis.*
	,, *ratticeps.*
	**Mus sylvaticus.*
REPTILIA	**Tropidonatus natrix.*
AMPHIBIA	*Rana temporaria.*
	**Bufo vulgaris.*
PISCES	**Acerina vulgaris.*
	Esox lucius.
	**Leuciscus rutilus.*
	* ,, *vulgaris.*
	* ,, *erythrophthalmus.*
	**Anguilla (?) anguilla (?)*

The party next visited a gravel pit at Sockett's Heath, little to the north of Grays. Here Mr. Hinton discussed some considerable length the questions raised by some of th valleys in the district as to their history and origin. The valleys are uniformly covered with the High Terrace grav which stretches over the surrounding plateau, but which in thes situations is proved to descend some thirty feet below its norm level. The speaker urged two things, viz., (1) that the valley were not the result of fluviatile or subaërial denudation operatin subsequently to the deposition of the drift, because none of th latter had been removed ; (2) that the valleys did not exist prio to the deposition of the gravel, because in that case they woul have been completely filled up with the gravel, or else equall effectually effaced by the erosive action of the ancient Thame The next point dealt with was that the Chalk and Tertiary stra of the Grays district form part of a small anticline. This foldi has produced faulting at other places in the Thames Valley, b in this district it has only opened a series of fissures. As instance of this the report of a previous excursion to Grays, under the direction of Mr. Spurrell, was cited. (*Proc. Geol. Assoc.*, vol. cii, p. 194.) In the opinion of the Directors the valleys were ormed through the dissolution of the Chalk along these lines of ssuring by acidic water. This solvent action had rounded off ie edges of the fissures, and had thus graved in the surface of e Chalk a series of grooves into which the superincumbent rata had descended.

Mr. Hinton then went on to contest possible objections to is view. He said that the first item that would doubtless be ought against it was the opinion of Sir J. Prestwich as expressed the memoir on "The Sand and Gravel Pipes of the Chalk" *uart. Journ. Geol. Soc.*, vol. xi, p. 71), but the only reply which : Directors had to make to this was that Prestwich's objections the view that fissures promoted solvent action were restricted the particular set of conditions which Prestwich had pictured that paper, and were not applicable to the present case, which s quite distinct. It was now generally held that the "Terrace" ucture seen in our river valleys was the product of an alternating ies of short periods of rapid elevation and longer periods of w subsidence. Adopting this view it was found that in High rrace times the land stood 100 ft. lower in relation to the sea n at present. There followed from this the conclusion that : saturation plane stood then just so much higher, relatively, to : land than now. With these conditions, by which the fissures came completely immersed below the plane of saturation, such currences became of great importance in regulating and favouring e dissolution of the Chalk. Some experimental observations of r. F. Rutley were then cited upon cubes of chalk immersed in lute acid, by which it was shown that the edges and solid angles ere the parts most readily attacked by the solvent (*Quart. Journn. Geol. Soc.* vol. xlix, p. 377). The speaker went on to say that heir views received further confirmation from the fact that, although he biggest fissures occurred on the top of the anticline, they had not given origin to the largest valleys. The reason for this was that their edges were soon placed by the elevation following the High Terrace period above the saturation plane, and so, by Prestwich's objection, beyond the reach of the solvent.

The party then examined the section, which showed in one part how the gravels had sunk in through the dissolution of the underlying Chalk. The President drew attention to the fact that in the garden of the house adjoining the pit a similar subsidence had occurred a few years ago.

The members then proceeded back through Grays to West Thurrock, and visited the Thames Works Quarry by the kind ermission of the owners. The section is very interesting, showg the brickearths of the Middle Terrace banked against an old halk cliff. Several members obtained bones and teeth from the brickearth, which were identified by Mr. Hinton as belonging to *Elephas primigenius*, *Bos* and *Equus*.

On the way back to Grays several fine sections exposing the High Terrace Drift, through the Thanet Sand to the Chalk were noticed. Tea was served at the "King's Arms," and the party returned to London.

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WHITSUNTIDE EXCURSION, 1901.

Directors: B. A. BAKER, S. S. BUCKMAN, F.G.S, Prof. C. LLOYD MORGAN, F.R.S., S. H. REYNOLDS, M.A., F.G.S., J. SCANES, and Rev. H. H. WINWOOD, M.A., F.G.S.

Excursion Secretary: A. C. YOUNG, F.C.S.

EXCURSION TO THE NEW G.W.R. LINE FROM WOOTTON BASSETT TO FILTON.

MAY 25TH TO 28TH, 1901.

Directors: Rev. H. H. WINWOOD, M.A., F.G.S., and B. A. BAKER.

(*Report by* H. H. WINWOOD.)

THE object of this excursion was to examine the important cuttings on the new railway, now in process of construction, between Wootton Bassett and Filton. Branching off from the former station, direct towards the Severn Tunnel, not only will a shortening of the mileage between South Wales and London be effected and the necessity of going round by Bristol, Bath, and Chippenham avoided, but, the gradients being less, the engines will be enabled to draw much heavier loads.

Saturday, May 25th—Seventeen members assembled at the Wootton Bassett station, and after a delay of 15 minutes for refreshment, started for their walk of 7¼ miles at 11.45. Under the grateful shadow of the first bridge that crosses the new line, the Director shortly explained the chief features of the geology of

o be traversed. Starting on the Oxford Clay, they
ıccessively over the Cornbrash, Forest Marble and
rs of the Jurassic series to the Rhætics and Keuper
ross from the eastern edge of the Bristol coal basin
n outcrop.

then began in a deep cutting of Oxford Clay. The
ınd slippery nature of this blue clay, though evident
was luckily not experienced as the dryness of the last
d rendered it hard and easily traversable. A few
fossils, *Gryphæa dilatata*, &c., were found, and some
of Oolite (not *in situ*) showed the usual corallian
. long embankment made of the clay from the cutting
ll the village of Brinkworth came into view. The
ıd Horses" was reached by a welcome short cut
ields, and after a short rest the line was again
elow the Church; here a spoil heap from a cutting
consisting of the more shaly beds afforded many
Alaria trifida, &c.) and one or two flattened im-
a tuberculated Ammonite, probably *A. Jason.*

of any great interest was seen to the east of Little
ut a small deposit of ferruginous-looking sand a little
: village attracted attention, as heaps of this had
sly noticed by the side of the line. (? Kellaways sand.)
cut to the left across the green fields to Great
as a relief from the cross-sleeper walking on the
the members not unwillingly entrained for Malmes-
comfortable hostelry of the King's Arms.

ıunt of the day's walk would not be complete without
ı the traces of plateau drift which capped the banks all
d was especially noticeable at Brinkworth. Many
ere pickedup, showing the ferruginous patina of the
and the white unstained surface of the original flint.
ractures artificial? If so, the supporters of the
ory have a rich mine to work, for the Director had
northwards to a height of 400ft., where from a bed
thick he had procured numerous flints similarly

aving Malmesbury an inspection of the Abbey was
ıe Norman south porch, with its six orders of sculp-
ive of Bible history, and the Saxon figures inside
ly noted. An excursion was also made to Garsdon
ıt two miles east of the town. At the sides of the
t leading out of the town are exposures of Forest
the large concretionary masses of calcareous sand
ıg out from the sandy layers, and known as "pot-lids"
ct. Crossing Milbourne Bridge and ascending the
t turn to the left led to a fine section of Corn-
: east of Garsdon Mill. The quarry, which has

existed for some years and is still being worked, showed the following section :

	Ft.	ins.
Top soil, with plateau flints	0	9
Brown clay	5	6
Yellow clay	2	6
Rubbly calcareous beds	2	0
Solid beds, getting more fissile at the base	10ft. to 15ft.	

The clays on the top of the quarry belong to the Oxfordian series. The rubbly beds with sandy layers below may represent the Kellaways rock. Fossils are abundant in the latter beds. The following, amongst others, were found: *Ammonites macrocephalus* in the nodules, *Terebratula lagenalis, Rhynchonella varians, Pholadomya murchisoni, Myacites, Goniomya literata, Modiola bipartita* (?), and Echinoderms. The numerous joints running through the lower beds of the Cornbrash filled with brown clay were pointed out, and attention directed to the junction of the Oxford Clay and Cornbrash, the exposure in the latter being one of the finest in the neighbourhood. Monday's walk would introduce the members to very thin representatives of that same rock resting upon the clays of the Forest Marble. The party returned through Charlton Park after inspecting the Church at the entrance, the chief feature of interest in it being the square Purbeck marble Norman font, supported by the usual pillars at its four corners. Some sections of Forest Marble close to the town were also visited.

Monday, 27th—The members left the hotel, where they had been made most comfortable, at 9.15 a.m. Passing through the village of Corston, on the Chippenham road, they turned to the right at Kingway Barn, and followed the winding lane to Bradfield, an ancient monastic building a little to the north of Hullavington. Here the work of the day began. Commencing with the Cornbrash at the base of the rails, this fine section, owing to the slight dip of the beds eastwards and their consequent rise westwards, gradually exposes the clays, sands, and limestone beds of the Forest Marble beneath for a distance of at least three miles.

The Director drew attention to the difference between the more solid beds of the Cornbrash seen at Garsdon and the broken-up beds before them. Were those five or ten feet, with the few inches of more solid but rubbly limestones beneath, brown on the surface but blue inside, representatives of the whole of those beds here deposited, or were they merely the bottom beds here remaining after denudation? He inclined to the latter view, and suggested a careful search for fossil evidence. The sharp line of demarcation between the brown limestones of the Cornbrash and the blue clays, from ten to twelve feet thick, of the Forest Marble was most marked. As the walk was continued ugh the cutting thin shaly beds rose above the rails, and e gradually succeeded by the more solid limestones at their e, crowded with the usual broken-up fossils, *Ostrea*, &c., racteristic of that formation, whence the name of Forest Marble n by William Smith in 1815 to similar beds in the Wychwood est. The blue clays in some parts of the cutting had been d with slag to prevent the overlying band of Cornbrash from ping down, and their exposure, at the present so well marked, be entirely hidden in course of time. Towards the middle of cutting the upper portion was overlaid by brown sands with eroidal masses of calcareous grit. The sand was fine and n, the usual blue colour having given place to brown by ng and exposure to the air. Still farther west a thick bed of stone, its surface covered with *Pecten*, cropped up, brown ns indicated the presence of pyrites and bituminised wood, some of the cavities in this bed contained hard ochreous s.

Leaving the line where the whiter beds of the Great ite just appeared at the base near the bridge over the Roman s-way, the vehicles were remounted at the first road which sses the line near Alderton, and, passing through Acton ville, the members rejoined the line a little to the west of vhouse Farm, thus avoiding a tedious walk along an embank- nt between Alderton and the latter place. Striking to the t across two fields, they suddenly came to a deep cutting ugh Forest Marble and Great Oolite at the eastern end of the nel through the Cotteswold Hills and east of No. 1 Shaft. hort halt on the top was called for luncheon, whilst a general ey of the section was made. The question arose, Where did Forest Marble end and the Great Oolite begin?—a very diffi- point to decide without closer examination. This was soon ertaken by a few who, despite the great heat of the sun, cended over the broken-up beds to the level of the rails. A example of the false bedding on the northern side called for camera of the photographer of the party, and after much beration it was decided that the Great Oolite began under the r of blue clay, two or three feet thick, not far below the top. ending to the higher ground, Shafts 1, 2, and 3 were passed, the débris did not afford any new features. Crossing through rove Plantation and making for No. 4 Shaft, a slight détour made to the right to inspect a good exposure of Forest Marble. quarry, however, had recently been filled up with the output n the adjoining shaft. This had been sunk as far down as *Cephalopoda*-bed, an iron-shot oolitic bed with characteristic ils. After topping the rising ground at No. 5 Shaft, the rgies of the members after their hot walk were greatly reduced, though one or two turned aside to collect some Fullers' th fossils from the spoil bank of this shaft, the majority made for the belt of trees which partly concealed the "Cross Hands," where much-needed refreshment restored their flagging spirits.

After this a short walk to No. 6 Shaft, the last of those on the Cotteswold Hills through which the tunnel, two and a half miles long, is being driven, was taken to find the richly fossiliferous iron-shot blocks of the *Cephalopoda*-bed. Unfortunately, these had been covered up; but the Director stated that *Ammonites bifrons*, *A. striatulus*, &c., had been found here by himself during former visits, and that this shaft had been sunk down to the clays of the Lower Lias. The abundance of water found in this shaft had impeded operations considerably. Leading them to the western edge of the escarpment, here 600ft. high, a grand view suddenly opened out right across the Bristol Coalfield and the Severn Channel to the hills of Monmouthshire in front, and along the escarpment of the Cotteswolds to Wootton Underedge on the east, the Tortworth district, the most northerly point of the triangular coal basin, being seen in the same direction, and the Church of Old Sodbury picturesquely nestling on the Marlstone escarpment below. A sharp descent down the tramway to No. 7 Shaft at Old Sodbury brought the day's traverse to a close, and after a drive through Chipping Sodbury to Yate Station the train was taken for Bristol.

Tuesday, *28th* —The members left by the 9.26 a.m. train for Yate, and drove to the place on the line where they had left off on the previous day to pick up the thread of the geological succession which they had then dropped. Walking through a cutting in Lower Lias clays, the first halt was made just to the east of a temporary bridge, where a "devil" recently at work had cut down into the Rhætics through the *Ammonites angulatus* and *A. planorbis*-beds. A band of blue clay about 3 or 4 inches thick, with the characteristic Ammonite, resting upon a thick bed of white Lias, indicated a change of deposit; and below this came an impersistent concretionary bed of Cotham marble, varying in thickness from 2 to 5 inches, continuous in some places, in others quite absent, and succeeded by light blue Rhætic marls. Passing onwards, the Lower Lias was seen to rest uncomfortably upon the upturned edges of the grits of the Upper Carboniferous Limestone. The surfaces of these grits, where exposed, had been rounded and water-worn, and were iron-stained, an ochreous deposit with hæmatite filling some of the joints. The lower beds of grit on the north bank were coarse and contained white quartz pebbles, and might easily have been mistaken for Millstone Grit did not this latter rock appear some hundreds of feet higher up in the series. The black bituminous limestones, getting more shaly westwards, and finally passing into oolitic and lighter-coloured beds with several bands of grit much finer in texture, and called by the quarrymen "firestones," had been deeply cut down, and exposed one of the best sections of the Upper Limees in the district. At the west end the New Red Marls, with Rhætic beds above, had been faulted against the Carboniferous estones, the marginal deposits of the Dolomitic Conglomerate ing been laid down previously. The history seems to be as ows. These Palæozoic rocks, planed down in pre-Mesozoic s, once formed an island, against which the waters of Liassic Triassic times had beaten and deposited their sediments; e then denudation had been at work, again planing off and ng bare the old land surface. Westwards the cutting deepened, osing a good section of Keuper Marls with the so-called a-green marls," capped by the "paper shales" of the Rhætics.

A traverse across green fields, under the guidance of Mr. B. A. er, was made to some interesting excavations made in these Red beds, for celestine occurring in pockets and veins ed up confusedly with Millstone Grit, and what were arently Coal Measure Shales; some fine specimens were ained.

The members were then driven back past Yate Station and r the Coal Pit Heath basin to the western edge of the al Field, and examined an old quarry near Huckford Mill Pennant Grit, on the south side of the lofty viaduct spanning valley, at the height of at least 100 feet. Ascending to line, after a few words from the Director with regard to the ition of this mass of sandstone separating the Upper from Lower Coal seams, and estimated at nearly 1,000 feet in this rict, they passed through the Winterbourne cutting in the e rock. The beds, dipping eastwards at about an equal angle those in the quarry beneath, consisted of thick grits, jointed broken up, getting more flaggy near the surface, much ed externally with oxide of iron, and with here and there spherical concretions. Suddenly terminating at the west a cutting in the road below exhibited the red and greenish s of the New Red, which had apparently been deposited nst the steep escarpment of the Pennant Grit, and covered a ression caused by a fault between this escarpment and other nant beds shown in an old quarry at Rye corner, farther west. Triassic Marls had probably covered the whole of Winter-rne Down, and, being finally denuded, left their representa-s in the hollow in question. Following a high embankment the next and last cutting, the Keuper beds were here well wn, with two or three marly calcareous bands near the surface taining a few patches of celestine. At the west end, and th of Stoke Gifford church, there was a good section of ætic beds with Keuper Marls at their base. On the south side eries of small steps brought the black "paper shales" to the el of the rails, with representatives of the *Ostrea*-beds of e Lower Lias overlying them. A thin band of dark crystalline d pyritous limestone, with fish scales and teeth, indicated the presence of the base of the Rhætics resting upon grey marly and earthy limestones. On the north side disturbances in the beds rendered the succession very obscure. At the N.E. end, close under the present brick-yard, a fault had brought the grey marls, representing the White Lias, right against the red clays of the Keuper, showing a sharp line of division from the one to the other, the change in colour being most marked. This series of small faults traversed the section obliquely from N.E. to S.W.

After tea at Stoke Gifford, a short walk to Fitton, where the train was taken for Bristol, ended the day's excursion. Messrs. Pearson and Son, the contractors, though unable to afford the members any facilities for locomotion, kindly gave them permission to walk along the new line.

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EXCURSION TO TORTWORTH.

WEDNESDAY, MAY 29TH.

Director: S. H. REYNOLDS, M.A., F.G.S.

(*Report by* THE DIRECTOR.)

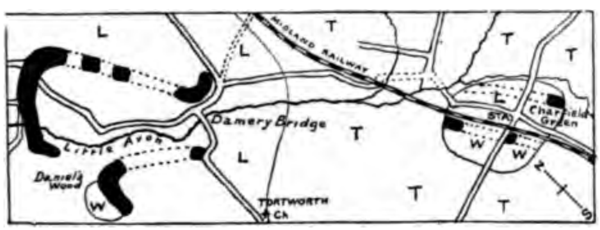
This day was devoted to an examination of the igneous rocks and associated sedimentaries of the Tortworth inlier, whose special interest lies in the fact that this district is the only one in Great Britain in which the occurrence of contemporaneous volcanic activity in Silurian times has been recognised. The trap rocks, which are all of the nature of pyroxene andesites or basalts, form two bands, which follow the northern and north-eastern boundaries of the Bristol coalfield. The upper band is overlain by beds of Lower Wenlock age; the lower is both overlain and underlain by beds of Upper Llandovery age.

The party numbering 22, left Bristol by the 9.12 train, reaching Charfield at 9.52. They then drove some little distance along the Charfield Mills road, and leaving the brakes, crossed the Midland Railway main line and entered an old quarry (Cullimore's) lying immediately W. of the line. The Director then explained that the quarry was opened in the upper and more westerly of the two igneous bands. Former observers had arrived at somewhat divergent conclusions with regard to these rocks, Murchison and Buckland, and Conybeare regarding them as dykes, while Phillips assigned them to a date contemporaneous with the rocks among which they occur. Phillips' view had been confirmed by the discovery of well-marked calcareous tuffs ssociated with the trap. One of these tuff bands occurred in ullimore's quarry, a small exposure in the western part giving he following section :—

Red marly shale, with a thin band of grey sandstone .	13½ in.
Calcareous tuff with Lower Wenlock fossils . . .	9 in.
Amygdaloidal trap	12 in

The members of the party collected a good many fossils rom the calcareous tuff, and also discovered for the first time ossils in the band of grey sandstone near the top of the exposure. The main part of the quarry is opened in highly amygdaloidal rap.

Rejoining the brakes, the party drove to the well-known uarry at Damery Bridge, where a fine-grained generally non-mygdaloidal trap, forming part of the lower of the two bands, is uarried for road metal. Underlying it are red micaceous shales,



Trap W. Wenlock
L. Llandovery T. Trias.

FIG. 6.—SKETCH MAP SHOWING THE IGNEOUS ROCKS OF THE TORTWORTH INLIER.
(Scale, 1 in. to a mile.)

ping S. 20° E., at an angle of 35°, and containing the ll-known Llandovery fossil, *Lingula symondsi*, of which fair number of specimens were obtained. Llandovery ssils were also collected in the hedge banks of the roads ning E. and S. from Damery Bridge, and abundantly in mall excavation beneath a cottage to the E. of the latter d. There the party lunched, and, rejoining the brakes, ve to the cross roads S.E. of Woodford Farm, where lower trap band, last seen at Damery, is exposed in the ge banks and round a little pond. The trap is here noticeable containing large patches of baked shale, one about 10 feet long, d also for the fact that it includes numerous grains of clear artz. Similar quartz grains are met with at a number of other alities in the district in both the upper and lower band of an.

The last spot visited was the old long-disused Middlemill or Horsley quarry, which is also opened in the lower trap-band. Here a central mass of much weathered and shattered trap has been left by the quarrymen, while the more compact material to the right and left has been quarried away. Overlying the trap along the western border of the quarry is a limestone, containing lapilli and fossils of Upper Llandovery age, especially corals. So that here, immediately overlying the lower trap-band, just as at Cullimore's quarry, overlying the upper trap-band, there are undoubted calcareous tuffs, whose presence strongly suggests, if it does not prove, that the igneous rocks with which they are associated are lava flows.

From Middlemill quarry the party drove back to Charfield, and returned to Bristol by the 6.0 o'clock train.

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EXCURSION TO DUNDRY HILL.

THURSDAY, MAY 30TH.

Director: S. S. BUCKMAN, F.G.S.

(*Report by* THE DIRECTOR.)

ON Thursday morning (May 30th, 1901) a party of sixteen drove at 9.30 to the west end of Dundry Hill. The carriages were left where the slope became steep, and the party ascended the hill, inspecting a section in the road to Castle Farm. Here the Director pointed out (1) that the part of the section near the field gate was presumably the Middle Lias below the Marlstone, but no fossils had been found; (2) that the position of a definite horizon, the *Ammonites turneri*-zone, of the Lower Lias was known at Barrow Reservoir, about 200 feet below; (3) that the Marlstone itself was absent from the particular section under observation, though found in other parts of Dundry Hill, a result due to penecontemporaneous erosion*; (4) that in the bank in the field the lower part of the Upper Lias might be found as a thin band of rock composed of beds of different lithic structure—a band similar to that shown to the Association on their visit to Down Cliffs, near Bridport—not an "aggregate deposit" any more than that at Down Cliffs because both here and there each bed had its own distinct lithic character and its peculiar fauna, so that the band of rock was polyzonal in each case; (5) that above the rock band were some 50 feet of clay—the *Dumortieria*-beds—form

* See S. S. Buckman, "Bajocian of the North Cotteswolds: the Main Hill Mass," *Quart. Journ. Geol. Soc.*, vol. lvii, p. 126.

ing truly the upper part of the Upper Lias; (6) that above the clay were the various limestone deposits known as Inferior Oolite.

The party then set to work to find the polyzonal band of Upper Lias, and after a little trouble were able to confirm the Director's statement by knocking out *Dactylioceras commune*, some fragments of *Hildoceras bifrons*, and portions of a *Harpoceras* allied to *H. exaratum*.

The party then crossed over the *Dumortieria*-beds to the well-known quarry at Castle Farm. Here, with a good outlook over the surrounding country, the Director was able to practically illustrate his remarks on the geological history of Dundry, and to give the following address, after pointing out the geography of the scene before the party.

Dundry is the most interesting of all Inferior Oolite localities; because by position it is an outlier of the Cotteswold Hills, but so far as its Inferior Oolite rocks are concerned, both in lithic structure and faunal contents, it belongs to the Anglo-Norman basin. Nothing is more remarkable than that the common Brachiopoda of the little-distant Cotteswolds are not found at Dundry, and the common Brachiopoda of Dundry are not found in the Cotteswolds, though the beds are strictly contemporaneous. For a definite period of Inferior Oolite time there must have been some barrier which parted the sea of Dundry from the sea of the Cotteswolds.

The genesis of Dundry may be said to commence at the close of the Carboniferous period. Then was formed to the south of it the west-to-east anticline of the Mendips; roughly parallel thereto a minor anticline of Wrington, evident in the carboniferous mass which bounds Dundry on the west; and this anticline probably dips beneath Dundry Hill (see Fig. 7). There was another roughly east-and-west anticline across the Avon, west of Bristol; and probably an eastward bounding anticline running north and south about the line of Bath.

This much-folded region suffered for some time from subaerial denudation; and during this period the Dolomitic Conglomerate collected as scree on the hillsides, to be afterward cemented by deposits from the waters of the Keuper, which occupied the irregular synclines of the Dundry area. Then followed the deposits of Rhætic and Lias; and there is evidence that the latter at any rate was laid down on a constantly moving surface. For the Mendip axis sank low enough to be nearly submerged by the Liassic sea (Fig. 7); and, according to the map of the Geological Survey, the junction line of Lias and Rhætic is some 300 feet higher on the south side of Dundry than on the north side, whereas the Inferior Oolite is nearly level (Fig. 7). This means that during Liassic time there was elevation both of the Mendip axis and of the Wrington anticline, with consequent penecontemporaneous erosion of Liassic rocks before the deposition of Inferior Oolite beds, causing considerably greater removal of Liassic beds on the south side of Dundry than on the north side.

There was penecontemporaneous removal, too, of Inferior Oolite rocks. The removal was not great; but the evidence is so clear, and the result is so disastrous to the palæontologist, in having robbed him of his most fossiliferous strata, that the fact bulks largely in his eyes.

In order to make the point clear, it is necessary to give the following table of the sequence of the Inferior Oolite and some Liassic deposits of Dundry:

DATES — Ages.	Hemeræ.	STRATA.	
PARKINSONIAN	Post Garantianæ	The Coralline Beds The Freestone	Upper Inferior Oolite
PARKINSONIAN	Garantianæ	The Conglomerate Bed	Upper Inferior Oolite
SONNINIAN	Sauzii	The Ironshot	Middle Inferior Oolite
SONNINIAN	Witchelliæ	The Upper White Ironshot	Middle Inferior Oolite
SONNINIAN	Sonniniæ	The Lower White Ironshot	Middle Inferior Oolite
SONNINIAN / LUDWIGIAN	Discitæ Concavi	Limestone and Marl Beds	Lower Inferior Oolite
LUDWIGIAN	Murchisonæ	Hard irony beds of Rackledown	Lower Inferior Oolite
LUDWIGIAN	Aalensis	Bottom beds (clayey stone)	Lower Inferior Oolite
HARPOCERATAN	Dumortieriæ	Clay Beds	Upper Lias
HARPOCERATAN	Dispansi to Bifrontis	The Blue Ironshot Beds	Upper Lias
HARPOCERATAN	Falciferi	The Pink Beds	Upper Lias
	Spinati	The Marlstone (Middle Lias)	

Between the Ironshot and the Conglomerate Bed strata of two hemeræ, *Niortensis* and *Blagdeni* (*Humphresiani*), are missing; and the Ironshot itself shows signs of erosion. But the Ironshot is only found in the middle of the hill. It does not extend to the west end, or even to the church; and eastwards the planing away of rocks is still more remarkable—all between the Conglomerate Bed and the *Dumortieriæ* beds has been removed at Maes Knoll.

What these facts, together with the absence of strata, seem to point to is this: that some time before the deposition of the

Conglomerate Bed the Dundry area was synclinated, the west and east ends of the hill being raised and then denuded, and on the level area so formed the Conglomerate Bed, or its equivalent, was laid down.

The annexed diagram (Fig. 8), drawn in accordance with the above ideas, will show the relative position of the strata, and will indicate the small syncline by which the Ironshot was preserved in the middle of the hill.

Now a word as to the separation of Dundry from the Cotteswolds during a part of Inferior Oolite time. From the hemera

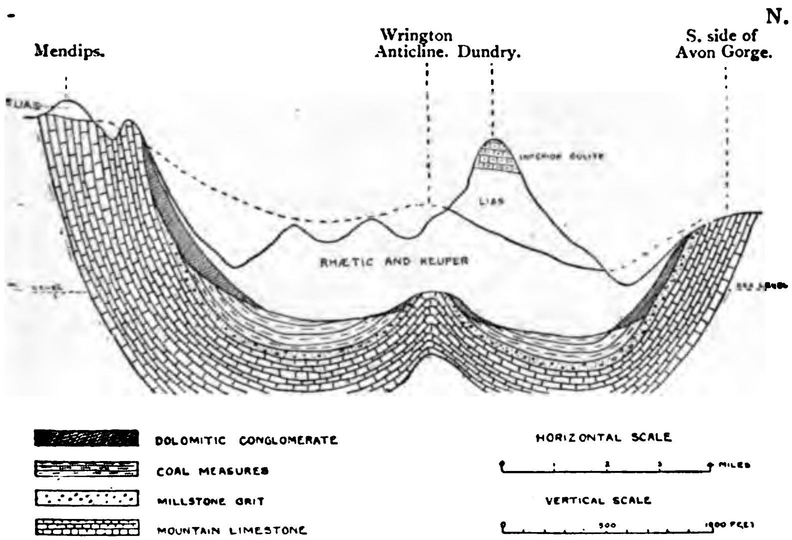

FIG. 7.—DIAGRAM SHOWING THE RELATION OF DUNDRY TO THE MENDIPS AND TO THE PALÆOZOIC ROCKS (*S. S. Buckman*).

Murchisonæ until the commencement of the hemera *Garantianæ*, Dundry must have been cut off from the Cotteswolds. With the evidence of earth movements at Dundry in Liassic and Inferior Oolite times, it is not difficult to understand how. After the *Dumortieria*-beds were laid down there was an earth movement with denudation : we have good evidence thereof in the Cotteswolds. Such a movement bringing to the surface Upper Lias or earlier rocks to the east of Dundry, and continuing in the line of the Malvern axis, might easily raise the necessary barrier. And there is some evidence for such a movement, because Fig. 8 shows that at a later date the east end of Dundry is more raised than the west end. At that time there must have been an anticline east of Dundry, denuded so as to bring, at Maes Knoll, the upper beds of Inferior Oolite in contact with the Upper Lias.

But if we cut off connection with the Cotteswold sea, it is necessary to have connection with the Dorset sea. That there was such connection the identity of fossil remains shows. Therefore the Mendip anticline must have been breached; and it was presumably broken somewhere in the line of the present Bristol Channel where the Holmes are. This breach of Jurassic date had perhaps much to do with the river system of the present day.

On that subject I would say a few words. We have built up Dundry to the top of the Inferior Oolite. No doubt there were

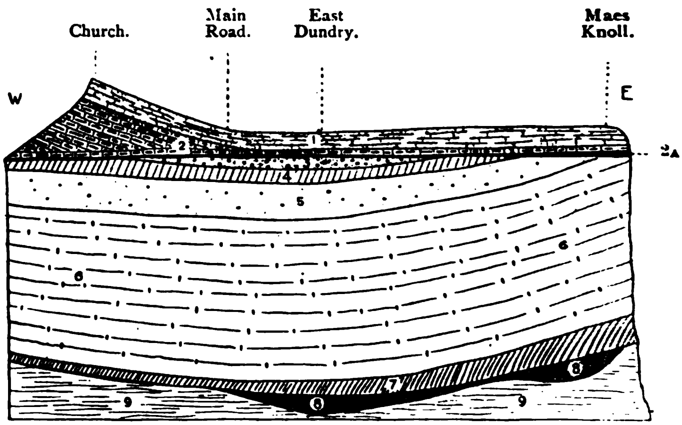

FIG. 8.—DIAGRAM OF STRATA AT DUNDRY *(S. S. Buckman)*.

1. Coralline Beds . . 2. Freestone . . . 2A. Conglomerate . .	Upper Inferior Oolite. (Parkinsonian Age).
3. Ironshot Oolite . . 4. White Ironshot . .	Middle Inferior Oolite. (Sonninian Age).
5. Lower Inferior Oolite .	(Ludwigian Age).
6. Dumortieria Beds . . 7. Bifrons Bed . . .	Upper Lias (Harpoceratan Age).
8. Marlstone . . . 9. Clay	Middle Lias (Deroceratan Age.)

many more rocks deposited on it; but we have no definite evidence. Our next episode is not deposition, but denudation—the carving of Dundry to its present shape. In this matter the Mendip and Wrington anticlines play a part; and between them was the Congressbury (pronounced Combsbury) syncline. This syncline would become the bed of a trough stream draining towards Keynsham, and the resultant river erosion would separate Dundry from the Mendips. On the north, excavation was effected by the predecessor of the Avon—a stream which flowed from Mid-Wales in a south-easterly direction, until coming under the influence of the Mendip anticline its further south-easterly progress would be checked, and it would be given a more easterly course. The next episode is the tapping of this pre-Avon river—accomplished by a stream which flowed south-westward from the Mendip anticline into the syncline between South Wales and North Devon (now the Bristol Channel, which in this part is a drowned out river valley). This stream working back, probably in the line where the Mendips had been breached in Jurassic days, and hence in a line of soft Jurassic rocks, got to the north of the Mendip-South-Wales anticline, and captured the pre-Avon river just north-west of Bristol. As a result, this stream would next start a stream in the pre-Avon valley, which, working back, would become the present Avon, capturing in turn

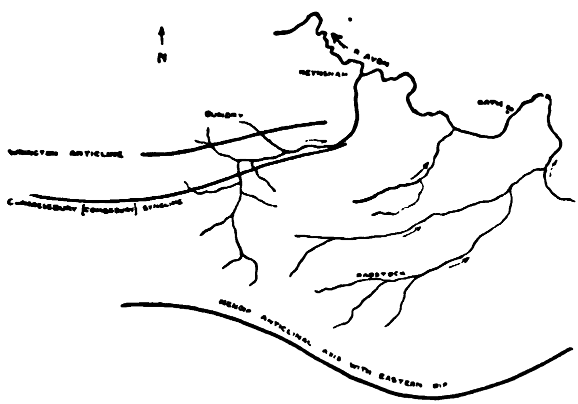

FIG. 9.—EASTERLY COURSES OF TRIBUTARIES ON SOUTH SIDE OF THE BRISTOL AVON, WHICH IS A WEST-FLOWING RIVER.

the tributaries of its predecessor. Of this we have striking evidence. Fig. 9 shows how the streams flowing from the north side of the Mendip anticline have a general north-easterly course, quite opposed to the course of the present Avon, which is generally north-westward. Like the remains of a Norman arch left in a church wall beside a perpendicular window, these streams remain as relics of a past age : they indicate the time when the main stream which they joined flowed in a direction opposite to that of the present Avon.

A word in conclusion concerning the suggestion that the Avon once travelled to the sea along the Nailsea Valley. Such an idea cannot be entertained for a minute. It is as if a man, having a direct way from his house to the road through a gate, should make for himself a longer way to the road, and break down a massive stone wall for the purpose. A stream having obtained a direct way to the sea through easily eroded rocks, is not going to leave it and take a longer course, involving the cutting down of a great barrier of hard rocks. The difficult may be abandoned for the easy, but not the easy for the difficult. The stream would not have cut the Clifton gorge unless compelled. It was compelled because the Nailsea Valley was then high ground filled with Mesozoic rocks. Therefore the lowering of the Nailsea Valley, by a process of differential subaerial erosion, has been accomplished since the time when the Avon was settled in its task of cutting the Clifton gorge. A little more lowering of the Nailsea Valley, and then the Avon will naturally make its course to the sea *viâ* that valley, leaving the Clifton gorge dry.

Some discussion arose on the points of this address; and then, the Director having made a few remarks on the rocks exposed in the quarry at Castle Farm, the party set to work to find fossils. Their labours were successful; but rain came on. When it cleared, and the party could leave the shelter of the quarry it was time to seek lunch at Dundry Inn.

After lunch the large Freestone Quarry by the church was inspected, and fossils were procured from the Coralline beds. Then the North Main Road Quarry was visited, but it proved to be out of work. However, the Director pointed out the Ironshot in the bank by the roadside; and part of a large ammonite of the genus *Sonninia* was obtained from the bed.

Rain again threatened; it was decided to drive to Maes Knoll, where, in spite of the wet and a cold wind, some of the members investigated a small opening, showing the Conglomerate Bed of the upper part of the Inferior Oolite resting on a bored and eroded surface of the Upper Lias, as illustrated in Fig. 8.

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EXCURSION TO AVON GORGE AND AUST CLIFF.

FRIDAY, MAY 31ST.

Under the Direction of Prof. C. LLOYD MORGAN, F.R.S., and Rev. H. H. WINWOOD, M.A., F.G.S.

AVON GORGE.

(*Report by* C. LLOYD MORGAN.)

A party of eighteen members and friends met Prof. Lloyd Morgan at 9.30 at Observatory Hill, Clifton Downs.

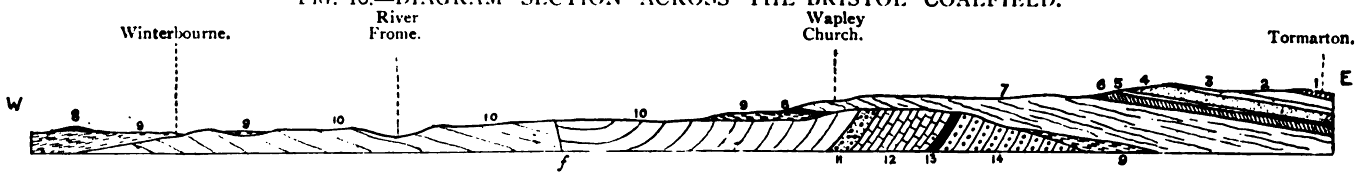
From this point a general view was obtained of the surrounding country, and the connection of the broader features of the landscape with the geological structure of the district was briefly indicated. The hill itself is composed of Carboniferous Limestone, the massive beds of which are here thrust up by the Clifton fault, strata of the same horizon being repeated on Durdham Down, farther north. Dipping S.S.E. at about 26°, the Lower Carboniferous rocks form the southern limb of an anticline, of which the northern limb is seen in the middle distance, the outstanding limestone forming the tree-clad ridge of King's Western Down. The arch of the anticline was denuded in pre-Mesozoic times, and on the Old Red Sandstone thus exposed, beds of Dolomitic Conglomerate were laid down unconformably. Beyond the northern limb lies the Severn, on the farther side of which are seen the Old Red Sandstone uplands of Monmouthshire and South Wales.

In the valley south of Observatory Hill lie the Coal Measures of part of the Bristol Coalfield, overlain by Triassic Marls. Beyond this is seen the Carboniferous Limestone anticline of Broadfield Down, the eastern end of which bears the Jurassic outlier of Dundry Hill. Further south rises the broad summit of the anticlinal arch of Mendip.

Before leaving the hill attention was drawn to a so-called "Triassic Dyke" (that shown by Buckland and Conybeare in their figure). A fissure in the limestone has here been filled in with fragmental materials, due to pre-Mesozoic denudation, and the whole cemented in a finer marly or calcareous material introduced in Keuper times. By the removal, partly through quarrying, of the limestone on either side, this now stands out as a vertical wall. Further evidence of the Keuper which once overlay the limestone was seen near the vallum of the British camp which crowns the hill.

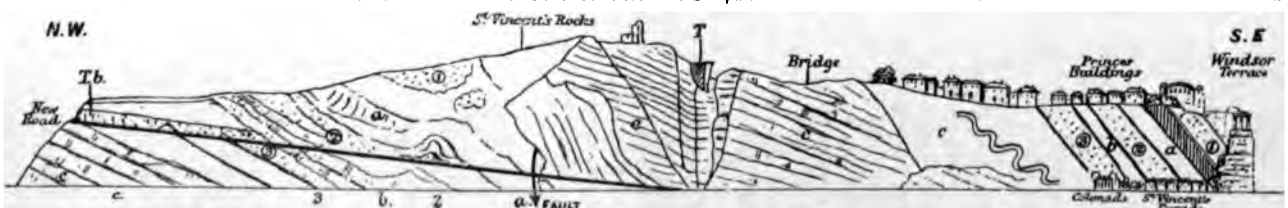
Descending somewhat and proceeding northwards the line of the Clifton fault was crossed, and in a few paces the Carboniferous Limestone was seen to give place to Millstone Grit, which shows abundant evidence of the effects of the neighbouring dislocation in its slickensided surface.

Fig. 10.—DIAGRAM SECTION ACROSS THE BRISTOL COALFIELD.



1. Great Oolite.
2. Fuller's Earth.
3. Inferior Oolite.
4. Sand.
5. Upper Lias Shale.
6. Marlstone.
7. Lower Lias Shale and Limestone.
8. Rhætic Beds.
9. Keuper Marl.
10. Coal Measures.
11. Millstone Grit.
12. Carboniferous Limestone.
13. Lower Limestone Shale.
14. Old Red Sandstone.
f. Fault.

Fig. 11.—SECTION ALONG THE RIGHT BANK OF THE RIVER AVON, SHOWING THE STRUCTURE OF CLIFTON DOWNS.



1, Millstone Grit,
2, Middle Grit.
3, Lower Grit.
a. Upper Limestone.
b, Middle Limestone.
c, Great Limestone.
T. Trias Dyke.
T. b. Trias Conglomerate.

Millstone Grit is overlain by Upper Limestone Shales, a
nal series showing alternations of grit and limestone
me shaly beds. These strata occupy the space which
es between the upthrust limestone of Observatory Hill
t of Durdham Down. Their surface was in pre-Mesozoic
lenuded so as to form a valley in which a fine tumbled
: Dolomitic Conglomerate (the local basement bed of the
) has been exposed in the Bridge Valley Road. The
l or sub-angular fragments included in this deposit are
cal origin derived from the limestones and grits close at
ınd some of them are of large size, weighing as much as
;. The valley depression in which they lie deepened
ls towards Cotham, and shelved up westwards across
sent (but then non-existent) Avon Gorge. On the
: or Somerset side of the river, some of the beds near the
nd of the old erosion valley may be seen lying uncon-
y on the upturned and denuded edges of the Lower Car-
ıus rocks. The pre-Triassic valley, or creek, occupied by
omitic Conglomerate is seen on the accompanying section
the P. of Promenade (Fig. 12).

ing down the road so as to cut the fault-line at a lower
me of the grit-beds of the Upper Limestone Shales were
d, and their lithological similarity to the local Millstone
s noticed. The overlying limestone beds were seen to
Lithostrotion irregulare, while some of them were found
arkedly oolitic in structure. According to Buckland and
are (Trans. Geol. Soc., 2nd series, Vol. I, pt. ii, p. 240),
per Limestone Shales in the Avon Section may be thus
ded:

Jpper Limestone having the usual character of Mountain
ne.

Middle grit, consisting of shale and grit alternating, and
a thin coal-seam.

Middle limestone, consisting of several beds having the
er of Mountain Limestone.

Lower grit, consisting of shale and grit alternating, and
two thin coal-seams.

r the foot of the road the lower grit of the above
ation was seen near the point where the line of the Clifton
s again crossed. The massive limestone of Observatory
iere thrust up over the contorted and torn beds of the
ie and upper grit which underlie the millstone grit already
a higher level. The throw of this reversed fault is between
ınd 1,200 feet. The direction in which the fault line
westward forms an angle of about 15° with the strike of
s, and cuts the strata in such a manner as to cause the
Limestone Shales to wedge out in that direction.

The line of section shown in the accompanying figure (Fig. 12) was then followed, the strata being traversed in descending order. Below the Upper Limestone Shales comes the upper part of the Carboniferous Limestone (U.L.). There was not, however, time to examine the beds, which contain *Productus giganteus* and *P. semireticulatus*, *Terebratula hastata*, and in parts abundant remains of *Lithostrotion*. The limestone is often foraminiferal, and contains *Calcisphæra*. Crinoid remains are relatively rare.

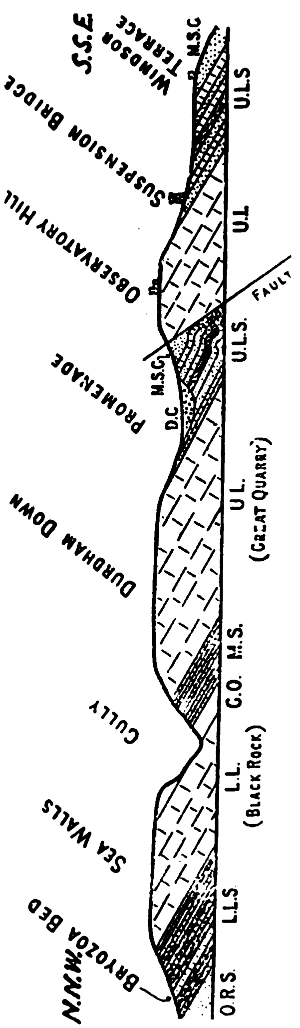


FIG. 12.—DIAGRAMMATIC VIEW OF THE BEDS EXPOSED IN THE AVON GORGE.

Beneath this Upper Limestone lie more fissile limestones and shaly beds containing *Micheldeania*, and hence termed by Mr. Edward Wethered the "Micheldeania Beds" (M.S.); and below this occurs a massive band of oolitic structure about 100 feet thick, locally termed by the Director the Gully Oolite (G.O.). This may be traced throughout the whole of the Bristol District. Near its base *Streptorhyncus* is often abundant. It is underlain by the Lower Limestone (L.L.) which has been worked in the Black Rock Quarry beneath the Sea Walls. This part of the limestone shows abundant crinoidal ossicles, and near the base where it passes into the Lower Limestone Shales it is largely made up of the remains of *Spirifera striata*. It is from the Lower Limestone that the greater number of the teeth and spines of Elasmobranch fishes have been found (*Orodus*, *Oracanthus*, *Cochliodus*, *Psammodus*, etc.).

Beneath the Lower Limestone lie the Lower Limestone Shales (L.L.S.) composed of thin-bedded limestones and marly strata. In its lower part, about 80 feet above the Old Red Sandstone, is a conspicuous massive red band, at first sight resembling a red sandstone, but mainly calcareous. This is locally known as the Bryozoa Bed. On solution in dilute acid it leaves a residue largely made up of minute fragments of organisms converted into peroxide of iron. Crinoidal ossicles preponderate, but Polyzoa (chiefly *Rhombopora*) occur in considerable numbers. Some 3 feet above the Bryozoa Bed is the so-called Palate Bed, of which some members obtained satisfactory specimens. It is conglomeratic, contains rounded pebbles of vein-quartz, and yields the teeth of many elasmobranch fishes, of which the commoner genera are *Helodus* and *Psammodus*.

Below the Bryozoa Bed are thin-bedded limestones and marls, in which Mr. W. W. Stoddart records *Modiola macadami*, a form interesting as suggesting a correlation of these beds with the Marwood Beds of Devon, and the Coomhold Beds of Ireland. There is no sign of unconformability between the Lower Limestone Shales and the underlying Old Red Sandstone. A conglomeratic bed with small pebbles of milky quartz is locally taken as the uppermost bed of the older system. A few feet below this, fissile beds, with abundant mica-flakes, occur; but many of the beds in the upper part of the Old Red system are here hard and conglomeratic.

Near Sea Mills Station the Dolomitic Conglomerate again occurs overlying unconformably the Old Red Sandstone. In the railway cutting the irregular cavities contained in the rock, some partially filled with calcite, others with quartz (Bristol diamonds) were seen; and a distant view was obtained of the relation of the older to the newer strata on the Somerset side of the river.

The following table gives the approximate thickness of the Lower Carboniferous rocks exposed in the Avon Gorge:—

	Feet.
Upper Limestone Shales	400
Upper Limestone (including Micheldeania Beds)	1,000
Lower Limestone (including Gully Oolite)	650
Lower Limestone Shales	320

AUST CLIFF.

(*Report by* H. H. WINWOOD.)

The members having finished their inspection of the Avon section, under the guidance of Prof. Lloyd Morgan parted from him at Sea Mills Station, and at 12.45 began their drive to Aust Cliff. Leaving the now ruined tidal dock, during the making of which, in 1712, many Roman remains were found, they followed the course of the Trym through Combe Dingle, left Shirehampton Park on the left and followed the road, skirting the north side of the Carboniferous Limestone ridge on which Blaize Castle is built. Henbury was passed on the right, a glimpse of the pretty Henbury cottages on the left and the hamlet of Hallen then came into view. Here the first halt was made to see a section of New Red Marl, with whitish streaks of some decomposed mineral traversing it from top to bottom (allophane?) The drive was then resumed through tortuous lanes across the alluvial flats of the Severn, and after passing through Northwich the members soon after alighted at what was formerly called "Passage House." The coaches formerly unloaded their passengers and mails here for what was then a dangerous crossing in a sailing boat to the opposite shore.

The party descended by the old Causeway to the shore. Taking shelter from the breeze, always fresh at this place, the Director remarked that the section before them was one of those exposed in the valley of the Severn, so often visited by former geologists. It had become classical, and was one of the earliest described exposures of Keuper Marls and Rhætic Beds in this district. Without entering into any details respecting these marls, he said that the whole section from the bottom to the *Ostrea*-beds of the Lower Lias measured about 120 feet. The base of the marls, resting upon the upturned edges of the Carboniferous Limestone, was sandy and gypsiferous. They would notice the sudden change near the top from red to grey. These grey beds, called by some "Tea Green Marls," indicated the horizon where the New Red series ended, and the ushering in of the Rhætic Series with their dark grey or black shales. The bone-bed, whence the finest collection of palates and teeth of *Ceratodus*, now in the Bristol Museum was obtained, they would see projecting from the Black Shales, with the Cotham Marble and White Lias above, succeeded to the top by thin representatives of the *Lima gigantea*- and *Ostrea*-beds of the Lower Lias. After this an examination of the fallen blocks was made during the walk along the base of the cliff, and many of the characteristic fossils, *Pecten valoniensis*, &c., were found. The search for these was much facilitated by Mr. Wickes, who had preceded the party in the morning and collected large portions of the bone-bed for their inspection. Some examples of this were very thick (quite 18 inches), of dark grey crystalline-limestone, crowded with bones and coprolites much rolled. Some good specimens of pseudomorphs of salt crystals rewarded a search in the grey-streaked marls near the base. The gypsum appeared at the east end of the section near the bottom in strings and small pockets. During the walk the President directed attention to the projecting masses of the cliff standing out like miniature headlands, explaining this by the fact that in every instance where the capping of Lower Lias Limestones existed the softer shales and marls below were preserved from denudation, and where these had fallen down, exposing the softer beds, the cliff had been weathered and furrowed back. This process was going on continually. Time and the rapid incoming tide warned the members to retrace their

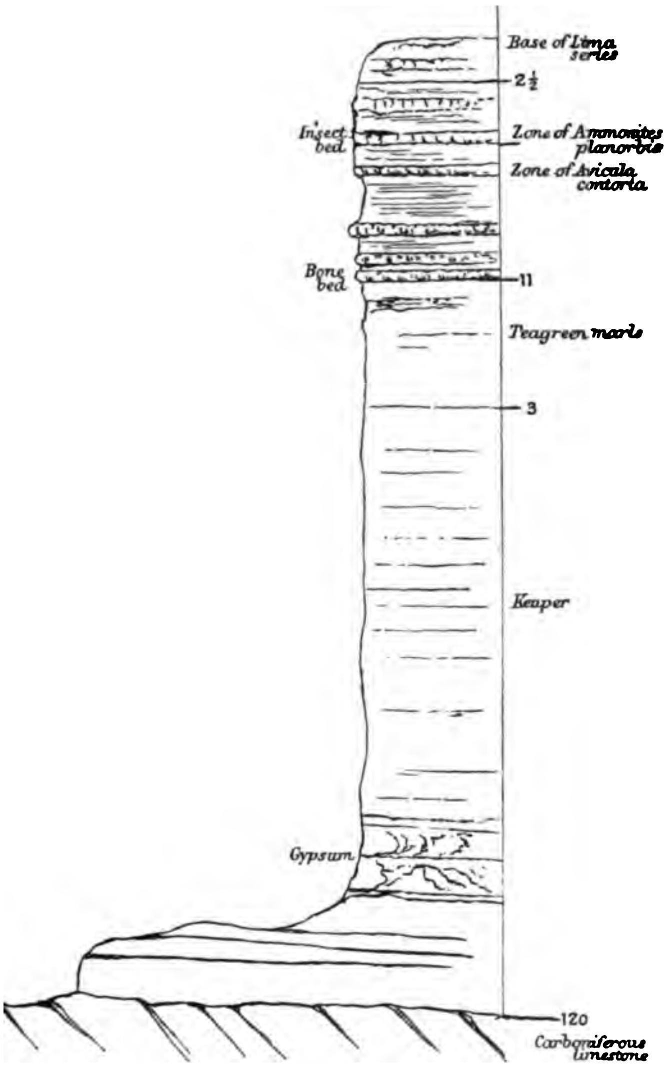


FIG. 13. SECTION OF AUST CLIFF.

steps, and after tea in a primitive arbour, overlooking the "Severn sea," the return drive was made to Bristol through Almonsbury and Henbury.

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EXCURSION TO WARMINSTER AND MAIDEN BRADLEY.

SATURDAY, JUNE 1ST.

Director: J. SCANES.

(*Report by* THE DIRECTOR.)

A party of ten members was met at Warminster Station, and proceeded by brake to Maiden Bradley. The drive through Sheerwater was much admired, notwithstanding that the azaleas and rhododendrons were not at their best.

Arriving at Maiden Bradley, a brief halt was made at the Somerset Arms for luncheon.

[A short time was devoted to the inspection of Mr. Scanes's very fine collection of Cretaceous fossils collected from this district, which were displayed in the schoolroom, and well merited a much more detailed study, before walking to the quarry, west of the school.—A. C. Y.]

After describing the section the Director drew attention to the Cornstone bed and brown fossiliferous sand, which presented the difficulty mentioned in the recent joint paper (*see* References at end of Report). From here the party was driven to Baycliffe Quarry, a few fossils collected from the spiculiferous beds, and attention drawn by the President to the peculiarly shaped valley, which might possibly have been made for irrigation purposes.

The two small pits at the back of Rye Hill Farm were next visited, but unfortunately very few fossils were obtained. The Black Hill Quarry, east of Rye Hill Farm, was visited, and a short time devoted to hunting for fossils before driving to the Crockerton Clay Pit, which is opened in the inlier of Lower Gault which comes to the surface at this spot. Owing to recent rain much water had collected, and explorations were practically confined to the heap of stuff that had been taken out for brick-making.

From the overlying drift the President secured a portion of an "elephant's tusk," and Dr. Blackmore, of the Salisbury Museum, one or two Eoliths.

From here the party drove back to Warminster and partook of tea at Mrs. Down's Refreshment Rooms, and, after a hearty vote of thanks to the Director, returned to London by the 5.34 train.

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EXCURSION TO CHEAM, EWELL, AND EPSOM.

SATURDAY, JUNE 8TH, 1901.

Director: W. P. D. STEBBING, F.G.S.

Excursion Secretary: A. E. SALTER, B.SC., F.G.S.

(*Report by* THE DIRECTOR.)

IN 1899 the Director conducted an excursion of the Geologists' Association to the west of London to see some sections showing the variation in the London Clay; the excursion this year (1901) was to the south-west, and to see the variation in the constitution of the Reading Series in neighbouring pits.

On arrival at Cheam at 2.45 the party, augmented by the cycling contingent, walked through the village northward to the brickfield owned by the Sutton and Cheam Brick Co., Ltd., passing on the way from the Chalk and over the outcrop of the Thanet Sand. The Thanet Sand is not exposed on the surface, but is said to be seen in the cellars of an old house south of the church.

The party was met at the brickfield by Mr. W. J. Bell, the manager, who conducted them to the fine section in the Reading Beds just north of the church. Here the Director made a few remarks on the exposure, which was in good condition, and on the narrowness of the outcrop, and quoted the President and other authors with reference to the beds and the conditions under which they were laid down. Mr. Bell then kindly spoke about the beds from a brick- and tile-making point of view, and mentioned the use of a certain narrow and discontinuous bed for making fire-bricks for lining gas-retorts.

A hole had been sunk at the bottom of the pit into the Thanet Sand, about 6 ft. of which was seen, just above which, in the "Bottom Bed," a greenish grey sandy loam, shark's teeth were found. No oyster-beds occurred in this pit, but they were to be seen in a brickfield a short distance to the east. The section showed about 20 ft. of the Reading Beds, and the surface of the ground was about 200 ft. O.D.

Retracing their steps northward and a few yards down the hill, the Director pointed out to the party a section in the London Clay, the identity of which was established not only by the difference in its clayey nature, but also by the immense number of septaria to be seen.

After a vote of thanks to Mr. Bell the party made their way back through the village, and then by Nonsuch Park Avenue, where the site of Nonsuch Palace was pointed out, to the historic section in the Reading Beds at Nonsuch Brick Kiln, east of Ewell.

This section was visited in 1886 under the leadership of Mr. H. H. French, who published the section then to be seen there. Owing to the pit on the north side being partly full of water, the complete section could not be seen, but below redeposited material, with flints and pebbles, beds of sandy loams and red and mottled clays were seen dipping to the north. On the south side of the pit grey glauconite sand, loamy clay, and tough blue clay were seen passing downwards into the Thanet Sand. The beds in this pit were first noticed by Mr. J. Middleton in 1812, and the fire-bricks for lining gas retorts made from one of the beds are famous over a large part of England.

Continuing the walk to Epsom by the springs of the Hogs Mill Brook, which are seen rising through the Thanet Sand, the party then visited the Linton Lane brickfield, an extensive opening to the north of the road. This section, at an elevation of 168 feet O.D., showed in different parts of the field the various beds of the Reading Series very well, particularly the fire-clay but no section down to the Thanet Sand was seen, owing to water having percolated into the hollows of the pit and filled them up.

Before leaving for Epsom the party entered the almost worked out pit on the opposite side of the road, just south of which, in the railway cutting, the Thanet Sand is to be seen.

After tea the Director, replying to the vote of thanks proposed by the President, expressed a hope that they were not disappointed with the excursion, which, though not affording great interest as regards its physical geology or scenery, was undoubtedly interesting from a stratigraphical point of view.

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EXCURSION TO ORPINGTON.

SATURDAY, JUNE 15TH, 1901.

Directors: T. V. HOLMES, F.G.S., and C. W. OSMAN, A.M.I.C.E.

Excursion Secretary: E. W. SKEATS, B.SC., F.G.S.

(*Report by* T. V. HOLMES.)

THE object of this excursion was to obtain another view of the sections exposed at the north of Orpington railway station during the widening of the line.

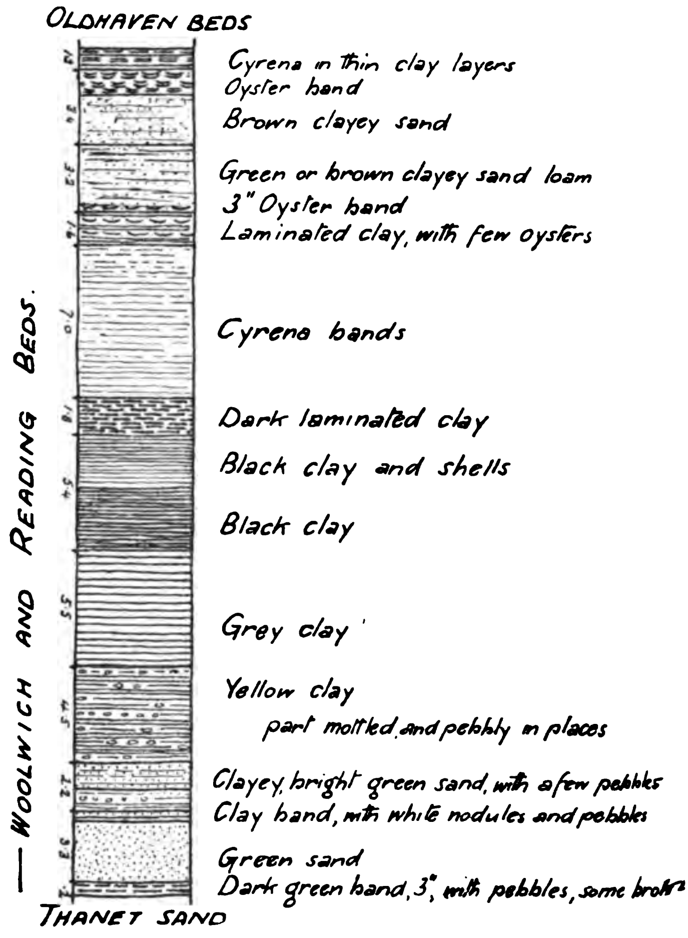
When these sections were visited in September, 1900, the Thanet Sand was clearly shown close to the railway station, and the shell beds of the Woolwich series were exposed only at, and four or five feet above, the level of the line east of Place Farm. On this occasion the Thanet Sand was hidden by fallen material, but the Woolwich Beds were admirably shown. Standing on the eastern bank of the cutting, where a footpath crosses the line, nearly midway between the railway station and the north-western corner of Clay Wood, the party obtained an excellent view of the Woolwich Beds on the opposite side. As quoted in the report of the previous Orpington excursion, in September, 1900, Mr. Whitaker, in "The Geology of London, and of part of the Thames Valley," says of this cutting that it must have given a fine section *when clear.* On this occasion, after a few general remarks from Mr. Holmes and the President, Mr. Osman unfolded a carefully drawn and elaborate section showing the details of the various beds exposed in the cutting during the widening, the result of his observations as engineer. The party then descended to the western side to note the characteristics of the various strata. The variegated clays seen at Cheam and Ewell on the previous Saturday were almost entirely absent, and were represented by bands of dark or even black clay. The diagram prepared from Mr. Osman's drawings, however, obviates the necessity of noting the details in writing. (*Fig.* 14.)

A few yards south of the bridge over the line, betwe Crofton Court and Clay Farm, the party stopped to exami some curious surface contortions in the side of the cuttir which was there only six or seven feet deep. Some discussi

FIG. 14.—THE ORPINGTON CUTTING.

(After C. W. Osman.)

Thicknesses given in feet and decimals.



arose as to how far they were probably due to changes resulti from the dissolution of shells, the spread and decay of the roo of trees, or the former existence of a stream at the spot whe they were seen. Then some trucks fitted with seats, which ha kindly provided by the contractors, Messrs. J. Aird and whose representative, Mr. Townsend, was present, bore ›arty through the London Clay in the Towncourt Wood ıg to a spot a few yards south of the L.C.&D.R. line. the junction between the London Clay and the underlying of the Oldhaven Beds was seen. Remounting the trucks, arty then proceeded to Chiselhurst railway station.

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CURSION TO HEATHFIELD AND BRIGHTLING.

SATURDAY, JUNE 22ND, 1901.

Director: CHARLES DAWSON, F.S.A., F.G.S.

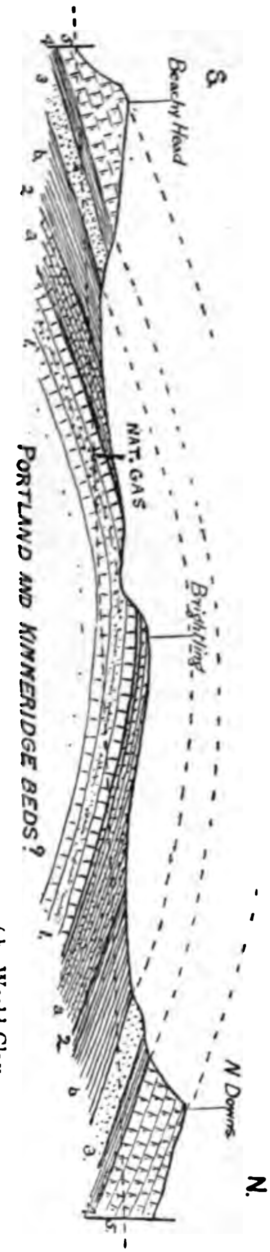
Excursion Secretary: E. W. SKEATS, B.Sc., F.G.S.

(*Report by* THE DIRECTOR.)

party arrived at Heathfield about one o'clock, and were met Ir. Dawson, who at once conducted them to the site of the ›rated "Natural Gas" well. Here sections and plans were 'n of the strata traversed by the boring. The Director, after g a short description of the strata over which the party had ›d in travelling from London, indicated upon a geological the proposed route for the day, showing that during their ıey they would cross and recross all the beds lying between Tertiaries and the Lower Purbecks. He then gave a short ınt of the discovery of the "Natural Gas," the full details ıich have already appeared in the *Quarterly Journal of the* '*gical Society* (Vol. LIV. (1898), pp. 564-571). The gas has ›een used by the L.B. & S.C.R. Co. to light their station ›ffices at Heathfield for two years, and such is its purity ›everal of the Welsbach mantles originally employed still n uninjured. A number of syndicates are now negotiating › further development.

he party then entered the carriages awaiting them, and pro-›d along the Wealden anticlinal in the direction of Bright-›eacon. Near the Crown Inn at Heathfield the anticlinal ›ates, one limb running N.E. and the other S.E. In the ' between these two branches are exposed by upheaval and ›lation the lowest layers of the Wealden formation (Ashdown s and Fairlight Clays) and the Purbeck Beds. Taking the along the top of the S.E. anticlinal, the party eventually ıed Dallington. Here the route struck across the strata lying een the two anticlinals. The highest point reached was ›tling Beacon, and at the Observatory the party descended the vehicles to enjoy the magnificent view commanded from that point. The landscape is bounded to the N. and I by the N. Downs, and to the S. by the S. Downs, while betv these two ridges of Chalk lies the extensive and rolling cou of the Weald. The Director explained that although they standing on one of the highest points in Sussex—646 feet al the sea-level—and apparently looking down on the hills boun the horizon, yet, geologically speaking, they were some 2,000 below the summit of those Chalk hills: the whole of the C Gault, and Greensands had been removed by denudation, anc present height attained as the result of upheaval. The gr upon which they were standing at Brightling and the s beneath for hundreds of feet had once formed part of the of a great river. The precise extent of this delta was not kn but that it had covered an enormous area was certain, for it been traced through Kent and Sussex westwards to the Is Wight and Dorsetshire, and eastwards as far as Belgium anc borders of Germany. At that period of the earth's history region must have appeared as a succession of sandbanks mudflats intersected by a network of small watercourses, subject at times to torrential floods bringing down sand and containing plant and animal remains from an unknown conti which the great river drained. Over these mudflats, as the dried them sufficiently, wandered the colossal land-reptiles o Wealden period, leaving their footprints on the half-dried and sand, in which also from time to time their remains be entombed. After the accumulation of many hundreds of fe sediment, the area of the delta was affected by a moveme depression, which resulted in its gradual invasion by the sea, the slowly deepening floor of which were deposited in succe the Lower Greensand, the Gault, the Upper Greensand, finally the Chalk. If they could restore, above the spot which they were standing, all the strata which had since removed by denudation, the summit of Brightling Beacon w be nearly 3,000 feet above the sea. After the deposition of Chalk, there set in an upward movement, and in the cour ages the whole of the S.E. of England and part of the adj coast of France rose in the shape of an elongated dome, al the centre and highest point (geologically speaking) being Br ling Beacon. Taking an ideal section of that dome from North Downs to the South Downs the appearance would be of a great solid arch, the highest course in which would be Chalk (Fig. 15). As the top of the dome slowly rose to surface of the water it was subjected to active wear and and the Chalk crown of the arch was entirely worn away the planing action of the sea. It was for that reason that loo on either side, to the N. and S., they saw the Chalk hills w now represent the bases from which the outer courses of the had sprung. Since the Wealden strata had been first thrown d and exposed, the surface erosion had been very great; this was exemplified by the great valley which ran from E. to W. between the two anticlinals on each side of Brightling. This valley and the smaller ones on either side (known in Sussex as "ghylls") had been excavated in past ages by the streams which now flow down them. The débris, which these streams carried, was building up a delta at the mouth of the Rother, in the same way, but on a much smaller scale, as the delta of the old Wealden river was built up ages ago from the débris of an older deposit.

The party then proceeded to Perch Hill Farm for tea. They afterwards inspected a few of the very numerous "bell-pits" which are sunk in the neighbourhood for the extraction of the Purbeck Limestone. The Director pointed out the mode of working, viz., by making a well three or four feet in diameter, and digging down to about forty feet, when the limestone is reached. The cavity above the stone is then "belled" on all sides to a diameter varying with the stability of the strata. The stone is then removed, and four small arched lateral chambers are dug at four equi-distant points in the side of the bell-shaped cavity, so as to extract as much stone as the pitman is able without endangering his life. The stone is conveyed to the top



5. Chalk.
4. Upper Greensand and Gault.
3. Lower Greensand.
2. Wealden. { b. Weald Clay. a. Hastings Sand.
1. Purbeck.

FIG. 15.—DIAGRAMMATIC SECTION ACROSS THE WEALD.

by means of a trug-basket and an exceedingly primitive windlass. The relation of the working of these pits in connection with the so-called "dene-holes" has already been discussed by Mr. Dawson and Mr. L. Holmes in the *Geological Magazine* (N. S., Dec. iv, Vol. v, 1898, pp. 293 *et seq.*). Ample time was given for the examination of the highly fossiliferous limestones ("Greys and Blues") of the Purbeck Beds, and numerous specimens of fish-, reptile-, and plant-remains were discovered.

On the return journey Mr. Lewis took charge of the party, and another route was chosen. The "Burwash Wheel"—a country inn alleged to be the foundation for the popular mistake of naming the locality "Burwash Weald," which really has no existence at all—was passed, and Tottingworth, the residence of Mr. Logie-Pirrie, was visited. Here Mr. Lewis explained that they were standing on the southern flank of the northern anticlinal between Heathfield and Burwash, and upon the site of a very early, probably pre-Roman encampment. It was of an oval form, the greatest diameter, from N.E. to S.W., being 140 feet, the least, from E. to W., 102 feet. Unfortunately a former owner of the estate was so annoyed by visitors to view the encampment that he did all in his power to eradicate it, and now it was very difficult to trace its outline completely. Luckily detailed measurements were taken some years ago, so that the actual dimensions are known. In early days the great anticlinal ridges were the land highways of the Weald, and the rivers the water highways along which the traffic in the iron trade passed. Encampments in the centre of the Wealden area were extremely rare, and this one might be a sort of resting station or *Col d'arbre* (vulgarised into "cold harbour") along one of the principal highways communicating from the Rother county with Lewes and Mid-Sussex.

On arrival at Heathfield the party proceeded to the Heathfield Hotel, where they dined as the guests of Mr. Henry Willet. Mr. Willet, who was the chief organiser of the Sub-Wealden Boring, was unable to be present, and in his absenc Mr. Dawson presided. At the conclusion of the dinner th President of the Association (Mr. Whitaker) expressed, on beha of the members, their very cordial thanks to Mr. Willet for h hospitality, and their regret that he was unable to be with ther After passing very hearty votes of thanks to the Director and Mr. Lewis, the party returned to London.

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EXCURSION TO STANMORE.

SATURDAY, JUNE 29th, 1901.

rectors : The PRESIDENT and A. E. SALTER, B.Sc., F.G.S.

Excursion Secretary : E. W. SKEATS, B.Sc., F.G.S.

(*Report by* MR. SALTER.)

party left Euston at 2.20 p.m., and arrived at Stanmore before three o'clock. A start was at once made for the er ground of Stanmore Common, *viâ* Dennis Lane, at the of which, and just on the border of the Common, at about feet O.D., a halt was made while the President referred to formation of the two large ponds near that spot. Proceeding 'ear Wood, a good section in Pebbly Gravel was inspected. Whitaker, in the absence of Mr. C. Reid, proceeded to give ons advanced by the latter for considering the deposit to be Eocene age. Mr. Salter followed, and gave a historical sum- y of the work that had been done with these deposits, and ected the evidence brought forward for their Eocene age riticism. He also shewed that the presence of foreign rial, the increase in complexity of the foreign constituents, decrease in height when the deposits are traced over a area, the fact that they overlie the Crag deposits at leton and are under the Boulder Clay at Ayot, and else- e, and their radial arrangement south of the gaps in the escarpment, all point to a Drift origin. If this were ase, then they must have been deposited by consequent ns *after* the folding of the London Basin. This folding is y attributed by geologists to *Miocene* times. A search in the elded a few foreign pebbles, such as quartz, sandstone, , dark-veined chert, &c.

fter tea at the Alpine Coffee Tavern, which is situated near ighest point in Middlesex, just over 500 feet above the he party took the road leading to Pinner, examining a pit Pebbly Gravel," at Harrow Weald, on the way. Here a junction with the London Clay was seen. The gravel was of a similar character to that seen before, except that liver-coloured quartzites and other stones suggesting a Bunter origin were found. No Lower Greensand chert was seen at either of the pits.

A pleasant walk, mostly through fields, brought the party to Pinner Station, and an enjoyable excursion to a close.

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EXCURSION TO TWYFORD AND THE WARGRAVE OUTLIER.

SATURDAY, JULY 6TH, 1901.

Directors: LL. TREACHER, F.G.S., AND H. J. OSBORNE WHITE, F.G.S.

Excursion Secretary: W. P. D. STEBBING, F.G.S.

(*Report by* H. J. OSBORNE WHITE.)

THE members arrived at Twyford about noon, and, meeting the Directors at the station, were conducted through the village to Mr. Treacher's residence, where about half an hour was spent in examining a portion of the large and valuable assemblage of stone and bronze implements, mammalian bones, and other objects of geological interest collected by the senior Director in the South of England.

In view of the visit of the Association, the glass table-cases in the museum had been arranged, as far as possible, so as to illustrate the local geology, but in the short time at their disposal the members were able to gain only an imperfect impression of the varied character and importance of the whole collection. Especial interest was manifested in the fine series of Palæolithic tools of flint and quartzite, obtained from the middle and lower terraces of river-gravel at Ruscombe, Caversham, Maidenhead, and other places in the valley of the Upper Thames; and the peculiarly massive character of some local specimens of the pointed type was a subject of comment. Among the examples of neoliths, collected from a somewhat wider area, a delicately-fashioned flint scraper, of the lunate form common in the Danish kitchen-middens, dredged from the Thames at Cookham, also attracted attention. Of the local fossils, mention may be made of a flint cast of a large ammonite of the *leptophyllus* group, from the Upper Chalk of the Waltham cutting on the G.W.R.

After refreshing themselves with the fruit kindly provided by Mrs. Treacher in the library attached to the museum, the members proceeded through the adjoining garden and meadow to Mr. Cotterell's brickyard, at Ruscombe. Here attention was first directed to the deposit of implement-bearing gravel overlying the Reading clays and sands. This gravel consists mainly of sub-angular and pebbly flints, with a noticeable number of the red and brown Bunter quartzite-pebbles characterising the Thames Valley Gravels, and of the partly rounded pieces of Lower Greensand chert occurring in the Southern Drift of the Loddon basin. It is really a mixture of two distinct gravels, the one essentially of north-western, the other of southern origin; and while the gently sloping area about Ruscombe now lies wholly within the basin of the Loddon, it must, at one time, have formed the debatable ground at the junction of that river with the Thames. In a section opened on the northern side of the brickyard, in 1893, a gravel of purely southern type was to be seen underlying one of north-western facies. The gravel seen in the western end of the workings on the present occasion had a much disturbed appearance, the stones being mixed with, and obliquely piped into the underlying sands and clays; but elsewhere the stratification was quite distinct, and the deposit clean and sandy.

Turning to the solid rocks, the Directors pointed out the variable and impersistent characters of the sands, loams, and clays forming the higher beds of the Reading Series at this spot. The pits surrounding the yard were all opened at about the same level, but the sections exposed in them possessed few features in common, and the succession of the beds had to be traced in a horizontal, rather than in a vertical, direction. At the north-western corner of the workings evidence of contemporaneous erosion was shown with diagrammatic clearness. A bank of stiff grey clay, with faint reddish mottlings and indistinct traces of bedding towards the top, exposed to a depth of about 15 ft. below the gravel, had been deeply channelled, and the hollow thus formed subsequently filled in with grey and yellow sands, the latter minutely current-bedded. Towards the south these sands were succeeded by loams with seams of light grey clay, affected by a strong south-easterly dip (apparently the result of current-bedding on a large scale), followed by horizontal beds of yellow and crimson-stained sands, rapidly giving place to a four-foot band of pale, bluish-mottled clay, resting on yellow sand. The southern face of the yard showed only banded mottled clay, exposed to a depth of between 20 and 30 ft., and forming part of a broad lenticular mass, on whose gently sloping flanks the beds previously seen appeared to rest.

The state of Mr. Treacher's health not allowing of his accompanying the party beyond Ruscombe, Mr. Osborne White, who took charge of the excursion during the rest of the day, led the way across the Bath Road, and by footpaths to the large chalk-quarry south of Wargrave. Here was exposed a fine vertical section, some 60 ft. in height, in the higher part of the Upper Chalk, belonging to the zone of *Micraster cor-anguinum*. The rock possessed the usual, somewhat friable, multi-jointed character, with frequent bands and floors of nodular flint, and a few subordinate seams of the tabular variety. A band of chalk, of more marly nature, was noticeable at about 3 ft. above the base of the section. Fossils are neither abundant nor well-preserved in this pit, but forms characteristic of the zone have been obtained by local collectors from time to time. The Director having pointed out the principal features of the section, and briefly explained the somewhat dangerous method of getting the chalk, by undercutting, employed at this spot, the members resumed their walk through the pleasant country on the western slope of the Wargrave Tertiary outlier to the "Horn Inn," near Cockpole Green, where a short stop was made for res and refreshment. Time did not permit of a visit either to the pit i Mr. Keeley's brick-yard at Crazies Hill, which is interesting chiefl by reason of the unusually large variety of the clays there occupyin a hollow in the light-coloured sands forming the upper part of th Reading Beds, or to the road-side exposure of the thin band unfossiliferous sandy limestone at the base of the London Cla near Holly Cross.

Lunch concluded, the members of the party ascende Bowsey Hill, but the fine view up the Kennet valley, usually be obtained from the summit, being obscured by haze, they once turned into the beech wood on the north-eastern slop where a few paces brought them to the newly-opened pits in t largest of the patches of pebble-gravel that cap the 150 feet or of London Clay forming the higher part of this eminen Classed by Sir Joseph Prestwich with his inland extension of t marine shingle typically developed at Westleton, near the Suff coast, in 1890, the Bowsey Gravel has been frequently examin and described by other observers in later years; but its tr origin and age—as also those of the other pebbly hill-gravels scattered along the northern slope of the London Basin—are still very doubtful. The deposit examined on the present occa-

:d to be irregularly banked against the higher part of stern slope of the hill. In many places it contained ixture of brown clay from the underlying rock, but, obably nowhere strictly *in situ*, its evenly-bedded ıd the purity of the yellow, and partly iron-cemented ıted with, or separating, the bands of pebbles near the deepest section, suggested that the amount of it had suffered had been but slight. The Director at although the gravels grouped as Westleton Beds by varying markedly as they do both in the nature and rtion of their constituents—had been found capable ion into a number of tolerably distinct varieties, he —so far, at least, as the patches in the north-western he London basin were concerned—they might be placed, according to their composition, under one or heads, viz., (1) a simpler and (2) a more complex. e first consisted of little but flint and quartz; the :ained a noticeable proportion of other rock frag- ıgst which the pebbles of pale-tinted quartzites, dark hert, banded lydite and veinstone, and a variety of l felspathic sandstones were the most prominent. The lex type, of which the Bowsey Gravel might be a good example, appeared to be unrepresented in the London basin drained by the Kennet, while the l found at Nettlebed and Greenmore, in Oxon., and ad been traced westward to beyond Marlborough.

;eneral discussion on the possible ages and modes of the deposit, in the course of which the President on its strong resemblance to the shingle at Westleton nd its unlikeness to any of the admittedly Eocene occurring in the London basin, the members searched stones removed from the pits, whence they speedily :cimens of the principal varieties of rocks represented, 6-inch cube of white vein-quartz.

g the track down the hill-side the party crossed a ly cut valley, where, to judge by the frequent traces of erosion is still very active. On reaching Warren proceeded eastward along the road as far as the common, where the Upper Chalk—locally employed acture of "whitening"—is obtained from underground 'he entrance to the older galleries was completely ı small landslip a few years ago, but the newer and less ›rkings are readily accessible by means of an adit › a small chamber of irregular plan, from which the 'erge. The attention of the members was directed to ›us bed of nodular flints, utilised as a roof to the nd to the numerous bands of stiff clay, exhibiting a ed structure, that had been forcibly squeezed into the joints of the chalk—probably on the occasion of the slip above referred to.

The sides of the open pit near the mouth of the adit showed the following section:—

		Feet.
	5. Clay Soil.	
LOCAL DRIFT.	4. Compact brown and grey sandy clay, with layers and masses of pebbles derived from the gravel on the higher ground in the vicinity	6—10
BOTTOM OF READING BEDS.	3. Laminated brown sandy clay	2
	2. Large, unworn, green-coated flints, with a few small flint pebbles, in grey and greenish sand ...	1
	1. Chalk, traversed by tubular cavities or borings filled with greenish sand to a depth of 3 feet below its even junction with bed above; and with layers of flint nodules.	

It was noticed that the above-mentioned borings, starting at the upper surface of the chalk, pursued regularly curving courses, independent of joint-planes, and while invariably circular in transverse section, appeared in some cases to taper downwards. In a few instances their sandy infilling was absent, its place being occupied by a plug of chalk, which could be removed like a sample of cheese from a taster, leaving a tube from half an inch to an inch in diameter, on whose slightly stained surface a faint striation was visible.

The majority of the members present seemed disposed to agree with Mr. W. H. Hudleston in attributing these curious tubes to the boring action of the roots of marine plants.

A short distance to the north-east of this spot the party was introduced to a pretty example of a calcareous spring, issuing from the upper sands of the Reading Series, on the slope of Ashley Hill. The water is highly charged with carbonate of lime, which is deposited as a brownish-grey crust on the twigs, chips of wood, pebbles and other objects in the bed of the ditch conducting it to the swallow-hole at the foot of the hill. Some of the specimens of "petrified" wood obtained showed only a thin granular, or oolitic, coating; others possessed a hard crust, still retaining the form of the stick, or twig, within; while in yet others the original nucleus had entirely disappeared, leaving a hollow or solid, roughly cylindrical, nodule of tufa. The rarity of such springs in the Tertiary areas of this country gives this example a peculiar interest. The thin bed of limestone occurring at the base of the London Clay is the most likely source of the calcareous matter.

Crossing the low ridge connecting Bowsey and Ashley Hills, the members reached Mr. Warner's brickyard, at Knowl Hill. In the numerous pits here opened, at different levels, in the ground rising towards the eastern spur of Bowsey, the following succession of beds, belonging to the Reading Series, could be made out—

		Feet.
	5. Yellow and orange sands, occasionally current-bedded ... ... about	20
	4. Bluish-red mottled clay, with signs of bedding towards the top	20
:DS.	3. Compact, pale blue clay, with loamy partings ...	2
	2. Laminated blue, grey and lavender clays, with lenticles of light yellow and brown sand, iron-cemented in places	1½
	1. Alternations of ash-grey clay, and sulphur-yellow sand, strongly current-bedded towards the lower part	13

t below which a bed of "gravel with oyster shells," ı the Chalk, was said to have been encountered.

eaf-beds here occupy much the same position in the series as they do at the type locality. How far they :neath the Wargrave outlier is not known, for the brick-vations are rarely carried below the base of the main ıottled clay, which, in this district, forms the most ally valuable, as well as the most persistent, member of ; but they are probably quite local. Few, if any, of bands and seams of clay in beds 1 to 3 are devoid of ns or coats of vegetable matter, and those of 1 and 2 ularly rich in the remains of leaves, stems of reed-like d seed cases. The yellow sands near the base of the lso, contain small pieces of lignite.

rt search yielded a number of good specimens of leaves, of which the impression of cellular tissue could be clearly and it wasnoticed that a common variety, of lanceolate alone represented along one fairly well-marked horizon.

ıid survey of the overlying clay and sand bringing the k to a conclusion, the members took tea at the Seven , where the President, in proposing the customary vote to the Directors, feelingly referred to the loss which the on had recently sustained in the death of his old col-ohn Hopwood Blake, of H.M. Geological Survey.

eologists then returned to Twyford by the Bath Road, in he 7.7. p.m. train to London.

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EXCURSION TO CHARLTON AND PLUMSTEAD.

JULY 13TH, 1901.

Directors: THE PRESIDENT (W. WHITAKER, F.R.S., F.G.S.), and T. V. HOLMES, F.G.S.

Excursion Secretary: W. P. D. STEBBING, F.G.S.

(*Report by* T. V. HOLMES, *with Notes by* THE PRESIDENT.)

THE party arrived at Charlton Junction railway station about 3 p.m., and, turning eastward, passed by way of Cedar Grove through the old chalk- and sand-pit, which has been the scene of some of the earliest excursions of the Association. This pit attained its greatest size some years ago, and, from not having been recently worked, its sections are not so clear as they once were. It has not, however, been occupied by the builder to anything like the same degree as Loampit Hill, Lewisham (another spot once much favoured by geologists), and still shows the dip of the Chalk and overlying beds very clearly.

East of this old pit the party entered that of Mr. Woodgate (who had kindly given permission for the visit), which is on the western side of the promontory, ranging nearly north-west and south-east, between the old chalk-pit westward and Maryon Park eastward. The sections here were in excellent condition, showing the top of the Chalk in the lowest part of the pit, the whole of the Thanet Sand, and the overlying Woolwich Beds and Blackheath Pebble Beds. The President, on calling attention to these details, also pointed out how strangely mixed together were the fragments of the upper beds forming the talus on the slope of the hillside. The party then made their way to the top of the hill, pausing on their route to look at the lower beds of the Woolwich Series, which had been worked back from the top of the Thanet Sand. On the top of the hill, ridges, which had once formed the western side of an old prehistoric camp, became visible. The greater part of this camp must have disappeared as the old chalk- and sand-pit, eastward, now Maryon Park, was enlarged, the ramparts at their south-western angle clearly pointing to its former extension eastward. Mr. Holmes remarked that he had looked into that part of the new edition of Hasted's "History of Kent," which comprised "The Hundred of Blackheath" (additions by Streatfield and Larkin, edited by Drake. London, 1886), with the view of learning something about this camp. On p. 123 he found:—

"Mr. Jones built a house in the centre of the old Roman encampment that overlooks the lower road to Woolwich; a small mass of the brickwork remained in 1837 on the brink of the sand-pit, which has destroyed half of the earthworks. A description of sand is there found which sold for a guinea a cubic foot, and the sides of the pit exhibit the geological strata, one of which is of shells, very distinctly."

On p. 134 was a note saying, "For notice of ancient earthworks at Charlton, see Archæol. Cantiana XIII, 15, with a Plate." On referring to the volume in question (1880), he found "Notes on Kentish Earthworks," by W. M. Flinders Petrie, a very short paper, in which more than fifty Kentish earthworks are briefly noticed. The plate shows the camp much as it now is, and there is a note stating: "Charlton. The banks along the side are on the slope of the hill below the edge. The faint ditches in the area are singular." The camp is shown on the Ordnance Map (6 in. to the mile). Probably it is British, not Roman.

The shell-beds of the Woolwich Series were most easily inspected by a descent of a few feet on the easterly, or Maryon Park, side of the hill, the platform in the pit at the top of the Thanet Sand being too low for that purpose. Reascending to the top, many shells were seen in the Blackheath Pebble Beds, where they had been worked for gravel at the south-western angle of the camp. The shells much resembled those of the Woolwich Series. Perhaps the chief point of interest in connection with them was their existence in the pebble-beds in irregular patches, sometimes only three or four feet beneath the surface. The shells, however, seem to have been protected here and there from the dissolving action of rain by a tendency to the cementing together of the pebbles by iron in small irregular patches.

After tea at Old Charlton, it was announced that Mr. C. H. Grinling, of Woolwich, had written to the Secretary of the Association, Mr. Emary, kindly mentioning the existence of some sections in a new road at the north-eastern corner of Plumstead Common. Most of the party decided to visit them before returning to London, and took train for Plumstead from Charlton Station. The road in which the sections were seen is incomplete, and may be reached by the footpath connecting Wickham Lane, close to its Plumstead end, with the north-eastern corner of Plumstead Common. On ascending, in a south-westerly direction, towards the Common, the top of the Thanet Sand, much covered by talus, formed the most easterly section in the new road. Higher up the hillside were seen the Woolwich Beds. They consisted of sand and pebbles at the base, above which is whitish sand, of which twelve feet or more were visible. The junction between this sand and the overlying shell beds was somewhat irregular. The shell beds (rather thin) consisted of a lower sandy bed, very full of *Cyrena*, and an upper one with fewer shells, more clayey and of a darker colour. This clayey shell-bed was cut off south-west by the Blackheath Beds. Above the Woolwich shell-beds appeared the sands and pebbles of the Oldhaven, or Blackheath, Series, which seemed to be slightly unconformable to the Woolwich Beds. Nearer the top of the hill the Blackheath Beds only were seen, consisting of sands with irregular masses of pebbles at top and bottom. Some of these pebble bands consisted mainly of stones much above the average size, others of stones unusually small.

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EXCURSION TO PULBOROUGH.

SATURDAY, JULY 20TH, 1901.

Director: J. VINCENT ELSDEN, B.Sc., F.G.S.

Excursion Secretary: W. P. D. STEBBING, F.G.S.

(*Report by* THE DIRECTOR.)

ASSEMBLING at Pulborough at noon, the party proceeded to examine the Lower Greensand beds in descending order. In a roadside section near the railway arch, close to the railway station, the base of the Folkestone Beds was first examined. The ferruginous sands are here covered with a thin bed of river gravel, containing rolled pebbles of flint, chert, and ironstone. Ascending the hill by the station, a fine exposure of the Sandgate Beds was then visited. This section has been recently opened for brick making, and shows about ten feet of bluish clay resting upon the same thickness of ferruginous sand. This formation is probably better developed in the neighbourhood of Pulborough than at any other part of the Wealden area, and the total thickness of the beds is estimated at 100 feet. The clays differ from the Gault, for which they were once mistaken, in being of a more sandy nature, requiring no further admixture for the manufacture of excellent bricks. In the sands beneath the clay, ironstone nodules are plentiful; but there is no record of fossils having been found in them at this spot. A layer of iron grit occurs at the base of the clays. The party then walked towards the village, and, ascending the hill towards the church, noticed that the road cutting exposed the same beds as were seen in the brickpit.

A short visit was made to the church, built of local stone, which, under the name of *Pulborough Stone*, has been dug for many years from the Hythe Beds in the neighbourhood. Inside the church there are several slabs of Sussex marble, the font also being of the same material.

Proceeding along the road past Old Place Farm the lane leading to Park Farm was reached, and here the sandy clays of the lower portion of the Sandgate Beds were examined, special attention being given to the ironstone nodule bed, which is here very fossiliferous. Specimens of *Trigonia alæformis*, *Cyprina*, a small gasteropod and other organic remains were secured. These were in the form of casts, and are fairly plentiful in the cutting on the eastern side of the lane, near the Park Farm gate.

The journey was then continued northwards to Pythendean, small exposures of the base of the Sandgate Beds being visible along the route. It may be useful here to recall Mr. Gould's subdivision of the Sandgate Beds of Pulborough, the whole of which are exposed between Pulborough station and Pythendean.

		ft. in.	ft. in.
1.	Shale and clay	30 0	
	(*Seen in part in Pulborough brickyard*). Thin parting of iron grit.		
2.	Yellow sand, sometimes hardening into soft sandstone	18 0	
	(*Seen in part in Pulborough brickyard*).		
3.	Sandy clay and clayey sand, with layers of fossiliferous ironstone nodules	12 0 to	20 0
	(*Seen in Park Farm Lane*).		
4.	Clayey sand	40 0	
	Passing gradually into Hythe Beds. (*Seen in Park Farm Lane*).		

The junction between the Sandgate and Hythe Beds is not clearly seen, but shortly after passing the brook in the lane leading from Park Farm, on ascending the dip slope, the nodular masses of limestone, occurring in the upper part of the Hythe Beds, were seen in the banks. The party then reached the summit of the escarpment above Pythendean. Here, on the face of the escarpment, is a quarry exposing a good section of Hythe Beds. A considerable amount of slipping has taken place here, and the beds are seen thrown over towards the face of the escarpment, in the opposite direction to the normal dip. Vertical joint planes parallel to the strike appear to have caused this movement. The stone quarried here is a soft calcareous sandstone in fairly thick beds. Fossils occur at this locality, but time did not permit of any prolonged search for specimens.

The party next made their way to the river, opposite Harwood's Green, where a boat was in readiness to ferry them over. On the opposite bank a halt was made for lunch. The

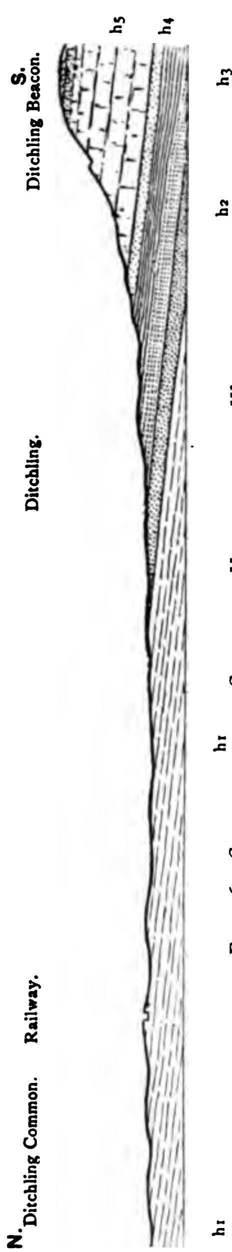

Fig. 16.—Section of the Southern Valley of the Weald. (Length about 4 miles. Vertical scale greatly exaggerated.)
h1 Weald Clay. h2 Lower Greensand. h3 Gault. h4 Upper Greensand. h5 Chalk.

Arun at this point is seen entering the Lower Greensand gorge and its valley contracts considerably as far as Stopham. Towards the north stretches a wide expanse of Weald Clay, with the curious eminence of Toat Hill in the foreground, described by Mr. P. J. Martin as a peninsulated mass of the uppermost Weald Clay. It does not appear that this eminence owes its preservation to any of the harder bands of sand or limestone which occur at intervals in the Weald Clay formation, although sandstone may be seen in an old quarry at Toat Farm, at the foot of the hill.

After lunch the first visit was paid to the brickpit at Harwood's Green. Here the Atherfield Clay is exposed, but the section is not very good. This locality has been described by Dr. Fitton,* who found here marine shells enclosed in phosphatic nodules. Many of these nodules were lying about the pit, having been rejected by the brickmakers. They are concretionary masses of a light brown colour, exfoliating on weathering, and one or two fragmentary shells were found in them. The clays contained a good deal of selenite, and were considerably stiffer than the clays of the Sandgate Beds. From their position at Harwood's Green, at the foot of the Lower Greensand escarpment, they might easily be taken for Wealden Beds, especially as the fossiliferous nodules were not seen *in situ*. There are other exposures of Atherfield Clay with interstratified sands, on the northern slopes of Bedham Hill and Flaxham Park Road, but time did not permit of these being examined. Ascending the face of

* See *Trans. Geol. Soc.*, Ser. 2, vol. iv. p. 156.

: escarpment towards Lithersgate Common, the route lay rough a well-wooded and picturesque country, from the higher :vations of which charming and extensive views were obtained the whole district between the South Downs and the central is of the Weald. The Hythe Beds on the western side of : Arun Valley present some features of difference from those served on the opposite bank. This formation here contains :onsiderable amount of chert in irregular beds and lenticular isses. The top of Lithersgate and Little Bognor Common has en everywhere dug for this substance, which is extensively ed as a local roadstone, and here are numerous openings from 1 to fifteen feet deep, where the mode of occurrence of the erty bands can be studied. It is curious that the chert is iown locally as *whin*. It is scarcely a true chert, but rather granular, quartzose rock, very hard and compact, the result of cretionary action in the sands. From the chert diggings of Little ognor Common the party now proceeded down the dip slope owards Fittleworth, crossing the various sub-divisions of the ower Greensand formation in ascending order, and stopping inspect one or two sandpits by the way. One of these near ittleworth Church was in Sandgate Beds, but a large pit at the wer end of the village afforded a typical exposure of Folkestone nds with a good deal of carstone. The contrast between the oded slopes of the Hythe Beds and the barren sands of tleworth Common was most marked. At the Swan Hotel, tleworth, a substantial tea was enjoyed, after which the party ceeded to the station with the object of giving up the remain- ; time to the examination of a fine section showing the junction the Gault and Folkestone Beds. This section is not now in best condition, owing to the large amount of slip which has en place in the overlying clays, whereby the actual junction somewhat confused. The typical "junction bed" does not ear to be present here. In its place is a bright red grit, a few hes thick, very hard and ferruginous, which is probably merely induration of the upper part of the Folkestone Beds. This grit l is apparently continuous for some distance eastwards, as it is in seen at the junction of the Gault and Folkestone Beds near lington, six or seven miles away. The normal junction bed hosphatic nodules has not been noticed between Petersfield Ringmer. Fossils were not found in the Fittleworth section, ough an impression of what seemed to be a portion of an nonite was secured.

Before leaving by the train for London there was an oppor- ity of seeing the fine example of a strike valley afforded by the er Rother, which joins the transverse valley of the Arun below Pham, just as that river emerges from the Lower Greensand ge. The Gault for some distance occupies the southern rgin of the Rother Valley, and at Hardham brickyard, seen from the train shortly after leaving Fittleworth, it rises above the alluvium, as a small inlier.

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ORDINARY MEETING.

FRIDAY, MARCH 1ST, 1901.

W. WHITAKER, B.A., F.R.S., President, in the Chair.

The following were elected members of the Association: Miss Norah Bodkin, Miss Cicely Ford, Mrs. M. M. Ogilvie Gordon, D.Sc., Ph.D., Alec W. Perkins, Miss Alice Sanderson.

The following papers were then read: "The Post-Pliocene Non-Marine Mollusca of the South of England," by A. S. Kennard and B. B. Woodward, F.L.S., F.G.S.; "The Pleistocene Fauna of West Wittering, Sussex," by J. P. Johnson.

ORDINARY MEETING.

FRIDAY, APRIL 12TH, 1901.

R. S. HERRIES, M.A., Sec. G.S., Vice-President, in the Chair.

The following were elected members of the Association: A. E. Broomfield, Mrs. Oswald Fitch, Henry Humphreys, M.D., Miss F. MacIver, Miss Margaret Spottiswoode.

The following lecture was then delivered: "The Zonal Value of Red Strata in the Carboniferous Rocks of the Midlands," by Walcot Gibson, F.G.S.

ORDINARY MEETING.

FRIDAY, MAY 3RD, 1901.

W. WHITAKER, B.A., F.R.S., President, in the chair.

Ernest H. Davison, A. J. Hardy, Bernard L. K. Henderson, A.K.C., George D. Patterson, Kenneth L. Reynolds, Ernest I. Shadbolt, Miss Alwine Simons, Miss E. M. Smith, LL.A., George H. D. Webb, Gilbert White, Rupert Williams-Ellis, and Fred W. Wilson were elected members of the Association.

A lecture was then delivered by Mr. A. Morley Davies, B.Sc., F.G.S., on "Geology and the Growth of London," illustrated by lantern slides.

ORDINARY MEETING.

FRIDAY, JUNE 7TH, 1901.

W. WHITAKER, B.A., F.R.S., President, in the Chair.

G. W. Bell, B.A., was elected a member of the Association.

A lecture was then delivered by Mr. John Parkinson, F.G.S., on "The Geysers of the Yellowstone," illustrated by lantern slides.

ORDINARY MEETING.

FRIDAY, JULY 5TH, 1901.

W. WHITAKER, B.A., F.R.S., President, in the Chair.

Humphrey Purnell Blackmore, M.D., F.G.S., George Clark, M.D., Francis Newman Ellis, George Francis Hill, M.A., A. H. Hines, Miss A. M. Humphry, and Frank E. King, B.Sc., were elected members of the Association.

The following paper was read: "The Volcanic Region of Auvergne," by the Rev. Canon T. G. Bonney, D.Sc., LL.D., F.R.S., late Professor of Geology at University College, London.

AN ADDITIONAL NOTE ON THE WHITE CHALK OF THE WESTERN CLIFFS OF DOVER.

By Dr. ARTHUR W. ROWE, F.G.S.

In Part I. of "The Zones of the White Chalk of the English Coast"—Kent and Sussex—(*Proc. Geol. Assoc.*, vol. xvi, pt. 6, Feb., 1900) the only zones which we discuss are those of *Rhynchonella cuvieri* and *Terebratulina gracilis*. We were fully aware, however, when we published this paper, that between Shakespeare's Cliff and the Coal Mine the cliffs were capped here and there by a greyer and more flinty chalk. While we were engaged upon this section we could find no proof of the exact nature of this chalk, for a careful search among the fallen blocks failed to reveal any evidence of a zone higher than that of *Terebratulina gracilis*.

In 1899, however, the outline of Shakespeare's Cliff was greatly altered by an immense fall from the top of the cliff, and during our visit this autumn we were enabled to assign the greyish and flinty chalk to the zone of *Holaster planus*. This bed is exactly similar in all its lithological features to the *Holaster planus*-chalk in the eastern cliffs, and the list of fossils which we append places the age of the zone beyond doubt.

Holaster planus,
Holaster placenta,
Micraster præcursor, } Of the group-form characteristic of the *H. planus*-zone.
Micraster cor-testudinarium, }
Micraster cor-bovis,
Micraster leskei,
Echinocorys vulgaris, var. *gibbus*,
Cyphosoma radiatum,
Pentacrinus,
Scaphites geinitzi,
Heteroceras reussianum,
Terebratula carnea.

The fauna was abundant, and we obtained fully 30 examples of *Micraster*, all of which showed the essential features of the test characteristic of the base and middle of this zone. All the examples of *Micraster præcursor* and *Micraster cor-testudinarium* had "sutured" or faintly "inflated" ambulacra, leading one to the inference that the upper part of this zone has here been lost. The cephalopods point to the existence of the zoological "Chalk Rock," which is well developed in the east cliffs. In any case we can confidently affirm that we obtained no evidence whatever of a fauna suggestive of the zone of *Micraster cor-testudinarium*.

The section at Shakespeare's Cliff affords us, therefore, a range from the zone of *Holaster subglobosus* to that of *Holaster planus*.

IE VOLCANIC REGION OF AUVERGNE.

CANON T. G. BONNEY, D.Sc., LL.D., F.R.S., etc., late Professor of Geology in University College, London.

(Read July 5th, 1901.)

UVERGNE, so far as my experience goes, is the most interesting region in France, if not in Europe. It can ch the geological student more about the natural history of canoes than the Eifel, or even than the neighbourhood of ples, though not a single vent is now in action. Impressive Vesuvius must be during an eruption, we have then to con- nplate it from a respectful distance, so that, although I would dly have witnessed this, I probably learnt more from being able stand on the crater rim. Auvergne offers to our examination wonderful series of preparations, the handiwork of nature, strative of the anatomy of a volcano, from crater-cones as fect as that of Monte Nuovo to ruins as complete as those on Fifeshire coast. These will principally attract your attention ring your visit, but they do not exhaust the geological interests the region.

The volcanic cones rise from a great upland plateau—a huge ular mass of ancient, and to a large extent, crystalline rocks— rounded by Secondary and later strata. Depressions in this teau were occupied towards the middle of the Tertiary era by ensive lakes, which were gradually filled up by beds of sand- ne, marls and freshwater limestones, the earlier of which are temporaneous with the Headon, Bembridge and Hamstead s of our country. You will frequently come across sections hem, especially on the western flank of the broad valley of the er, sealed up sometimes under sheets of basalt. As the lakes ppeared, probably owing to changes of level about the nning of the Miocene period, volcanoes became active on central plateau, and continued in eruption, with occasional ses, during the rest of the Tertiary era, and almost down to oric times. It is this episode in the history of Auvergne which made it classical ground since the middle of the eighteenth tury, for here especially the weapons were forged which early in following one gave the death blow to those Wernerian dogmas ch had been so serious an impediment to progress in geology. e Scrope and Lyell, Murchison and Sedgwick learned to read ht Nature's book of hieroglyphics, and here also during the third of a century the details and relations of the rocks have n worked out by some of the ablest geologists in France. It be my endeavour, while not passing over other topics in olute silence, to lay before you a brief outline of their ncipal conclusions.*

* As it is now, I regret to say, a quarter of a century since I was in Auvergne, I have ed far more to the works of these authorities (of which a brief list is appended by way ostscript) than to my own notes written when I was little more than a beginner etrology

As the traveller approaches Clermont Ferrand along the broad valley of the Allier, he is greeted by a view no less impressive than characteristic. The fertile river plain is bounded by the steeply sloping scarp of an undulating plateau rising more than a thousand feet above it.* This scarp, consisting partly of the granitic substructure, partly of lacustrine beds, to which sheets of basalt often form a coping, is seamed by gullies and furrowed by the deeper glens of the stronger streams, and sometimes has been carved by rains and rivers into bastion-like promontories. Above this long but irregular fortress-wall rises a line of boldly-outlined hills, most of which are obviously volcanic cones, though two or three, and notably the highest one, have a less distinctive, though still peculiar, outline. This singular view, more than any other characteristic of the "Puy"† region, though attractive at all hours of the day, is never so impressive as at sunset, when these strange, almost weird, summits loom out in purple shadow against the glowing western sky. The upland plateau, no doubt, sometimes wears a barren aspect, with its rugged surfaces of lava, its wild moors and its coarse vegetation, but the volcanic cones, apart from their geological interest, never allow the view to become monotonous; the valley slopes, here craggy, there richly wooded, are often picturesque, and their beds in broadening out present a charming contrast by their fertility, while the mountain scenery around Mont-Dore (Fig. 17), and occasionally in the Cantal, is really grand. On my second visit‡ I was there for a full fortnight without a companion and never felt lonely, for one's thoughts were always occupied and eyes delighted, even when one rested from work in the field. I have seldom seen a view which has struck me as more beautiful than that from the edge of the volcanic zone across the rich river-valley of the Allier to the blue line of the Forez hills.

Geologically and geographically Auvergne is an insulated region, and that fact has left an impression on its history. Here, the primitive and the archaic have lingered longest; here, any importation from without has been resisted and modified by that which was indigenous. Its archæology, its architecture, its chronicles, and its people—all are marked by distinct and home-born characteristics. Auvergne is rich in prehistoric remains. It is not without those of Palæolithic man, but to find them in abundance we must look beyond its western border to the

* The height of Clermont Ferrand above sea level is 1,335 feet, of Gergovia 2,441 feet, and the mean elevation of the plateau is given as rather more than 3,000 feet.

† Puy, or pué, a name for a hill, apparently used in the southern part of France, is connected with the Italian *poggio* and the Latin *podium*, one meaning of which (especially in "Low Latin") is a hill or high place. The word, as applied to isolated crater-cones, or lava-domes, has of late years made its way into geology, the "puy stage" designating the one (usually late in the volcanic history of a region) signalised by numerous sporadic outbreaks.

‡ On this occasion I spent a short time at Le Puy en Velay, just glanced at the Cantal, and devoted the remainder of the time to the Mont-Dore and Puy de Dôme district. My first visit was no more than a brief halt at Clermont Ferrand in order to get a general idea of a volcanic region.

FIG. 17.—THE CLIFFS OF SANCY.

FIG. 18.—A DYKE IN THE HIGH VALLEY OF CHAUDEFOUR.

limestone gorges of the Dordogne and neighbouring rivers. There, in the caves of Aquitaine, the hunters dwelt, like the Horites of Palestine, but no doubt they often pursued the reindeer, the aurochs, the horse, and even the mammoth into the wild uplands of Auvergne. But the relics of their successors—the people of the Neolithic, the Bronze, and the Early Iron ages—are abundant. Such an upland as Auvergne forms a natural camp of refuge when a native race is being pressed back by a stronger invader. Thus it is a land where the prehistoric is overlapped by the historic. The hill forts of the home-born Gauls may be contemporaneous with the camps of the Italian soldiers. Cæsar was driven back by Vercingetorix from the ramparts of Gergovia, and was obliged to raise a siege which brought him no credit, though he was ultimately victorious.

The Romans ruled Auvergne and have left their mark, not to name other localities, on the great "high place" of the Puy de Dôme and in the road not far from its base, about the springs of Mont-Dore, and in the subsoil of Clermont Ferrand. To the lover of architecture, Auvergne is hardly less attractive than to the geologist. Ruined castles, often picturesquely perched on a crag of volcanic rock, are abundant. So also are ancient churches, and their features are not less characteristic than those of the

region. The Romanesque architecture of this province, accor
to Fergusson*, attained a degree of independent complete
which enables us to class it among the more perfected styl
Europe. Fine examples are to be found at Issoire, Orcival,
St. Nectaire, in the church of Notre Dame du Port at Clern
Ferrand and the cathedral at Le Puy. Nor must we forget
Michel's Church in that town, on its rocky pinnacle, or
fortified church of Royat, or the cathedral of Clermont Ferran
though that is in the Pointed style, for it was begun in 1248—
its fine stained-glass windows dating from the later part of
and the following century.

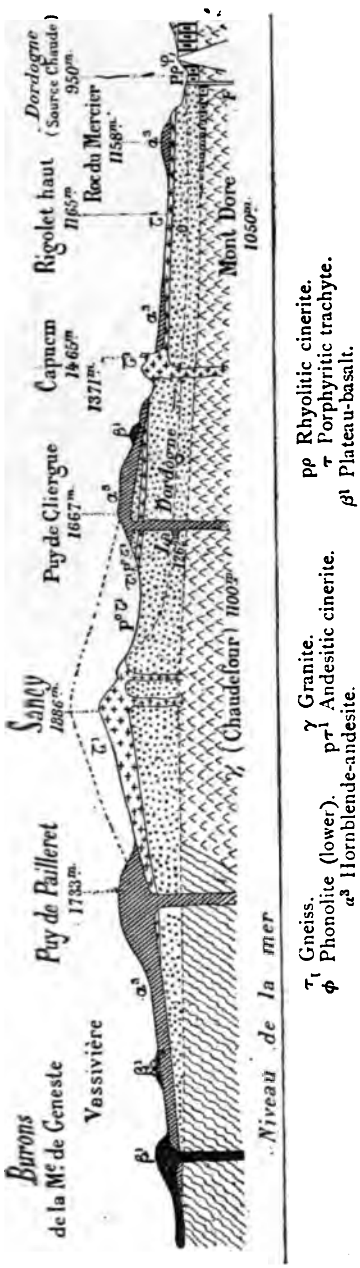
The insulated character of the region has also impressed i
on the people. A highland race, they preserved for long a
tain independence, and may still be reckoned among the ne
representatives of the ancient inhabitants of Gaul. The Auver
of the original stock is a member of the short, dark, bra
cephalic race which entered France in early Neolithic times
still survives in ethnological islands such as this hill region. I
and industrious, many Auvergnats seek employment, especiall
domestic servants, in Paris and other cities to the north, wl
their rusticity, stolidity, and patois have made them stock fig
in comedies and the lighter literature. To the passing trav
they appeared a simple and kindly folk, and we must not fo
that this Bœotia of France has given birth to a Lafayett
Polignac, a Gregory of Tours, and a Pascal.

Turning now to the Geology of Auvergne, we may divide
summary into three heads: the fundamental plateau, the
deposits, and the volcanoes.

The Fundamental Plateau.—A glance at a geological
of France shows us a huge island, consisting largely of crystal
rocks, which lies rather on the south-eastern side of the centr
the country, and is surrounded by Secondary and some
deposits from the Triassic or Jurassic upwards. In outline it rou
imitates that of France, but on the southern side it is pie
by the newer rock, as by a broad fjord, on the eastern margi
which the mountainous Cevennes rise to a height of 5,584

On the east it is sharply defined by the valley of the Sa
and the lower Rhone, towards the west and south it shelves n
gradually downwards over the limestone uplands of Les Causs
the cañon and cave district of France. Well in the south of
crystalline highland rise the Loire and its great tributary, the Al
The rivers from its western and most of its southern slopes ei
take an independent path to the Atlantic, like the Charent
discharge themselves into the Garonne. The remainder of
south and the east drains to the Rhone; but sends thither
affluent of any importance. As this great crystalline *massif*
probably retained an insular character from early in the Secon

* History of Architecture, Book iii, ch. iv.



era, the leading lines of its valleys may be very ancient, so that the first-named fact has a special value in relation to past physical geography.

But insulated as this Auvergne *massif* appears to be, it may nevertheless have some connection with the crystalline and palæozoic regions of Brittany and La Vendée, and even of the Pyrenees. From those of the Western Alps it is certainly inseparable. But with this question we must abstain on the present occasion from entangling ourselves, though we shall find it impossible to leave the last-named region entirely out of sight. I pass on, therefore, to the constituent rocks of the Auvergne plateau. These are largely gneisses, sometimes containing cordierite, and mica-schists; a granular variety of the former being more abundant on the eastern side, as the latter are on the western. With them are associated some rocks of a dioritic character, the so-called amphibolite. These, which occur in elongated masses, I think will be ultimately found to be mainly, if not wholly, rocks of igneous origin. They are in greater abundance to the east of the region which you are intending to visit, but have been observed near Brioude, Saint-Flour and Marcenat. The gneisses and schists are invaded by granite, which rock underlies the greater part of the Velay volcanoes and occupies no inconsiderable area in the more western district; the mica-schists and gneisses entering more largely into the foundations of the Cantal, the Mont-Dore and the chain of Puys to the north of it. In this region, however, from Enval on the south to the Saut de la Pucelle on the north, we find a mass of rocks, certainly of clastic origin—phyllites and quartzites—and early Palæozoic, or possibly Pre-Cambrian in age. These are unconformable with the gneisses and schists, but are pierced and altered by the granite, as may be seen at the Puy Chopine, about Theix, and near the Lac Chambon. Of later date are some isolated deposits belonging to the Carboniferous system, of which the most important is the well-known coalfield of St. Etienne. A narrow zone of the same age may also be traced for many miles west of the volcanic groups of the Puy de Dôme, Mont-Dore and Cantal. The granite is generally coarse, and not seldom porphyritic; in some places it becomes hornblendic; it is frequently much decomposed at the surface, so that it might be dug into with a spade. Fragments of the rocks, through which it has broken, are not uncommonly included, and have sometimes been apparently in part absorbed. This granite is cut by veins of a finer grain and in better preservation, and felstones, allied to porphyrite, occur in parts of the region. This fundamental *massif* has been profoundly affected by at least two separate sets of earth movements; one, perhaps of a complex character, in the closing years of the Palæozoic era, the effect of which was the insulation of the plateau, and the other, of Tertiary age, which operated more especially before the beginning and at the end of the Miocene period.

Each of these great disturbances, according to Prof. Michel Lévy, produced a series of anticlinal and synclinal folds. Those of Pre-Mesozoic age, in the western part of our region, trend, though with much irregularity, in a general west to east direction, or parallel with the great Hercynian folding of the northern districts, the effect of which may be traced from the south of Ireland to some distance east of the Rhine in Germany. Notwithstanding this, the Carboniferous strata in Auvergne show signs of another folding along lines parallel with those which have so markedly affected the deposits of the same age in the Western Alps.* From the close of the Palæozoic era onwards to the later part of Eocene times, the geological history of Auvergne is a blank. It again becomes legible in the Oligocene. When this period began, according to M. Boule, Auvergne was a land of great lakes, more or less directly communicating one with another; their surfaces probably being not very much above the

* Our own country, more especially in the northern part, bears testimony to two great post-carboniferous and pre-mesozoic foldings; the earlier W.S.W.—E.N.E., probably only a modification of the Hercynian movements; the later a N. and S. folding, by which the present outline of the Pennine chain was determined.

he sea which at that time extended over the Paris basin. the great earth movements which were giving birth :isting Alps may have produced in this region minor which blocked the course of rivers and converted valleys ;. Changes of level apparently occurred once or twice e Oligocene, which gave a temporary admission to the onverted the lakes into lagoons.

*Lacustrine Deposits.**—These lakes, according to the uthorities, were not less than three in number. The :alled the Limagne d'Allier, has been separated by nt earth movements into two basins, those of Clermont ınd of Issoire. The second lake was in Velay, the third great extent hidden beneath the volcanic mass of the All have been filled up by deposits of a similar char- it will suffice to take the first as an example. It was ger than the Lake of Geneva, and its depth exceeded

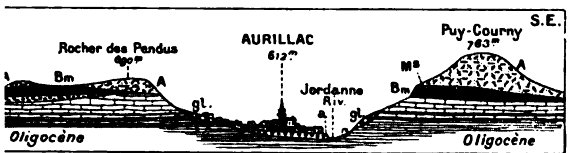


FIG. 20.—SECTION AT AURILLAC.

ı Miocene basalt. Ms Fluviatile sand, Upper Miocene.
Andesitic breccia. gl Glacial formations.
a Alluvium (ancient).

produced, with the permission of Messrs. Masson and Co., publishers, f Paris, from the *Guide to the Cantal*, by M. Boule and M. Fargés.)

et. The lowest deposit consists of a considerable ; of arkose† interstratified in places with variegated clays, less sandy. The former represents the débris of e rocks swept down by streams from the neighbouring mong these beds occur such plant remains as *Betula* *m* and a palm, with some shells which indicate a Middle ly Lower Oligocene age. These deposits as a whole may oo feet in thickness, and are followed by representatives of tanian or Upper Oligocene, limestone and marl more or ıreous, with stratified peperite‡ in the upper part. The livision, about 164 feet thick, contains *Potamides* In the next, about the same thickness, are *Limnæa*

paragraphs are mainly condensed from Professor De Lapparent's account of deposits of Central France (*Traité de Géologie*, pp. 1493 *et seq*. Ed. 1900).
: is a quartz-felspar grit. What I saw was fairly coarse, obviously the detritus rock, the felspar being rather decomposed. In places, as near Royat, it is l with bitumen. The Torridon Sandstone and the Grès Feldspathique of ınd Alderney are "arkose" of more ancient date.
ltic ash cemented by calcareous mud.

admitted by De Lapparent*—(1) Burdigalien, (2) Helvetier Tortonien, (4) Sarmatien, (5) Pontien (in ascending ord only the first and third—the Burdigalien and the Tortonien certainly represented. The former is identified, for instan Gergovia in some marly limestones and fluviatile sands bet the two sheets of basalt (the upper one capping the hill which Scrope calls attention. They contain *Melania aquita* with shells of the genera *Melanopsis*, *Unio* and *Cyrena*, be remains of such plants as *Myrica lignitum*, *M. lævigata*, *La primigenia*, *Cinnamomum lanceolatum*, *Liquidambar europæ* plants with some Australian affinities, and suggestive of a v and rather dry climate. The Tortonien (from which possibl Helvetien is not separable) is represented by deposits assoc with lava flows and beds of ashes (as near St. Gérand-le-Puy Puy-Courny, near Aurillac), which have yielded *Dinothe giganteum*, *Hipparion gracile*, and *Machærodus cultridens*. I other localities come, in addition, *Rhinoceros schleiermacheri Tragoceras amaltheus*.

The Pliocene is also represented. At Perrier, near Iss occur in ascending order: (*a*) conglomerate, (*b*) cinerites,† sands, (*d*) trachytic breccia, with a fauna indicative of Middle Pliocene. The relations of these with formation earlier and later date are shown in Fig. 21. In the Canta cinerites—in one place 3,035 feet, in another 3,215 feet, a sea level—which contain, besides species of *Acer*, *F Quercus*, *Tilia*, and ferns (some not now European), *Sass ferretianum*, and *Oreodaphne heeri*. The tuffs of Varen near Murols, and of the Bourboule, are also Pliocene—t have furnished several species of oak, some Asiatic—while in Velay the middle group of that system contains *Mast arvernensis*, *M. borsoni*, *Tapirus arvernensis*, and beds diatoms. In the last, other plants occur, also exhibiting Ori affinities. Volcanic action continued during this period, signs of glaciation occur before its end, which, however, we leave for the present.

The Volcanoes.—These, which had now become impo features in the landscape, form two principal groups. western one begins at its northern end with the chain of I west of Clermont Ferrand and the neighbouring part of the A and runs on to the huge pile of Mont-Dore; this is lin by an isthmus to the still more extensive *massif* of the Ca and it throws off to the south-east the long promontor Aubrac. The eastern group is more like a cluster of islands principal of which are the hills of the Velay, the Mézenc

* *Traité de Géologie*, pp. 1518 *et seq.* (Ed. 1900).

† Stratified volcanic ash more acid in character than the peperites, *e.g.*, of an materials.

Coirons.* It is evident—almost at a glance—that the noes differ greatly in age.† There are some, like the great

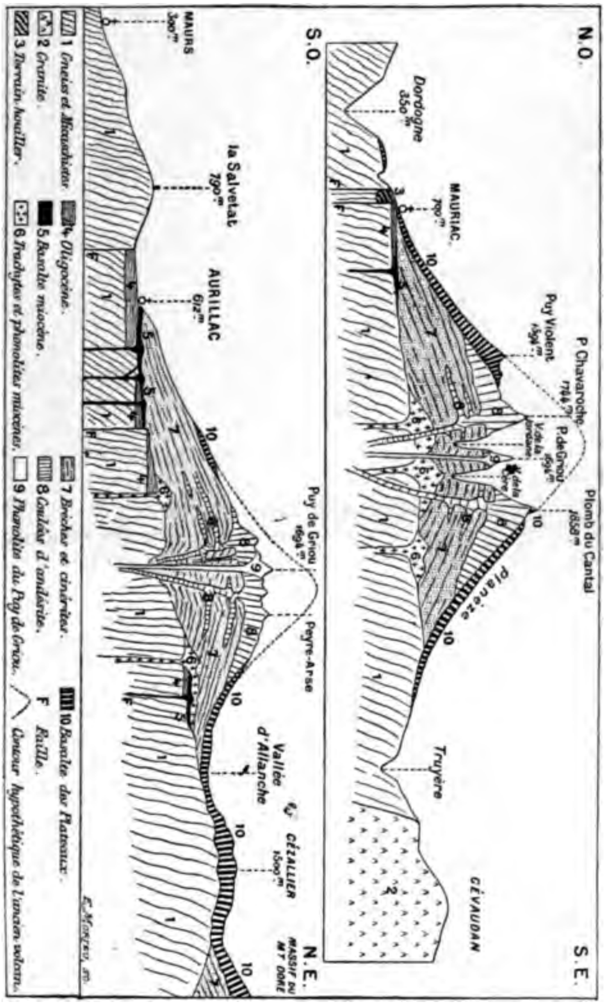


FIG. 22.—SECTIONS THROUGH THE CANTAL MASSIF.

s of the Sancy and the Cantal, from which every trace central crater has disappeared; there are lava flows which

* A few scattered vents occur in the Forez hills to the north of this group.

† *Livret Guide, Int. Geol. Cong.*, 1900, *Massif Central*, p. 5. The volcanic action is con-d by Prof. Michel Lévy to be related to the great earth movements which raised ps, as will be indicated more fully below.

are furrowed deep by valleys, carved into cliffs, insulated denudation, as, for instance, at Gergovia and on the west margin of the Limagne; while other cones—like many of Puys in the northern group—show no signs of weathering, : other flows, with surfaces rough, and only a little less fresh t those on the flanks of Vesuvius, may be seen descending above-named valleys on to the present river plain. It may as already said, that a few vents—probably insignificant—ope before the close of the Oligocene; but early in the Miocene must picture the lakes replaced by broad fertile plains, throu which the rivers wandered, and enclosed by an undulati region of crystalline rock, probably well clad with vegetatic with here and there a cone. Even during Miocene times the o breaks, apparently, were moderate, but became locally mc intense during the Pliocene, and built up the two great cent masses of Mont-Dore and the Cantal (Figs. 19 and 22). The were formed by the repeated emission of lava streams from o or more closely connected centres, and in some cases the mater has not flowed far; at a rather later epoch, however, it was mc fluid and the places of discharge were apparently more numero The materials vary from very acid types, such as pitch-stones a rhyolites,* to basalts, with some trachytes, and occasional phor lites. The first-named, however, are rare; the majority range fr andesites to basalts. These are divided by not a few authc ties, well qualified to form an opinion, into andesites, lab dorites and basalts. For convenience, I shall adopt their nom clature, though I think the second name to have been formed a wrong principle† and to be hardly necessary, for it expresses more than a rather basic andesite or a rather acid basalt. (classifications are to a considerable extent arbitrary—created our convenience, not to fetter nature—and are, I think, less lik to mislead us, if we frankly admit great precision to be unatt able. In justification of this criticism, I will quote from analy printed by Prof. Michel Lévy, taking the two extremes in e list:—

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MgO.	CaO.	Na_2O.	K_2O.	H_2O.	
Andesite.	62.04	20.13	1.84	3.17	0.52	4.17	5.47	2.69	0.11	
	54.62	18.73	10.09	—	2.68	7.31	2.91	3.02	0.52	
Labra-	55.21	18.74	—	8.34	2.98	6.01	5.81	2.97	0.56	
dorite.	52.31	17.83	13.63	—	3.68	6.11	3.41	2.46	0.25	§
Basalt‡	50.31	22.95	—	6.60	5.29	8.19	4.30	1.00	0.30	§
	48.57	19.47	—	13.53	4.25	10.86	1.33	0.82	0.48	§

* Occurring mainly low down in the Mont-Dore Mass, near La Bourboule.

† A rock should not be called after a mineral unless it is almost wholly compos the latter. Thus pyroxenite, hornblendite (amphibolite is often misapplied) and peridotite are correct, but no one could assert that labradorite mostly consist labradorite felspar.

‡ There is one in the list with SiO_2=53.2, but I abstain from quoting this, though it w strengthen my point, because the analysis seems a rather rough one.

¶ The S.G. is not given, but that of another rock with an almost identical ana is 2.88.

§ In the three rocks thus indicated there is a little MnO, respectively 0.29, 0.93, 0.76.

In these analyses the silica percentage conspicuously declines, hat of the alkalies does so in a less degree, the protoxide bases listinctly increase,* the alumina undergoing no very marked :hange. So on chemical ground I can see no reason for separatng the second of the labradorites from the basalts, or the first rom the more basic of the andesites. Whether to call them basic ndesites or acid basalts seems to me a matter of indifference, and hould be determined by the general aspect of the rock. They are, in fact, on the border line, whatever we may name hem.

Many varieties of the above-named volcanic rocks will be ound, to which doubtless your attention will be directed in going ›ver the ground.† The trachytes, for instance, as may be seen in he upper part of the Sancy and in the famous Grande Cascade ection, sometimes contain large crystals of sanidine; the former ılmost resembling the well-known trachyte of the Drachenfels. Some of the andesites contain hauyne; hornblende and biotite ıre not unfrequent accessories. The basalts vary from compact o porphyritic, containing olivine, augite, etc., and the volcanic ocks not seldom include fragments of the older masses through which they have broken.

In the table annexed (p. 201), as M Boule remarks, some of the eruptive products have their position fixed by intercalated fossiliferous deposits; the contemporaneity of others may be inferred rom their petrographic identity and correspondence in succession. A close connection obviously exists between the two great masses f the Cantal and of Mont-Dore. In the latter, indeed, eruptions ontinued to a more recent date, but the great central volcanoes robably became extinct about the same time. Discharges ppear to have ceased first in the Mézenc and Mégal districts; › have begun latest in the Velay, where remains of *Mastodon rvernensis* show that the earliest outbreaks occurred in the Middle Pliocene. Volcanic disturbances evidently ceased in the astern districts earlier than in the western; in both the outreaks probably began, and certainly ended, later in the north ıan in the south, unweathered craters being especially numerous ı the Puy de Dôme district. Phonolites occur in both regions, specially in the southern portions, being most abundant in the Mézenc mass, commoner in the Cantal than in Mont-Dore, and bsent from the Velay and the northern chain of puys. The lomites of the last region are considerably older than the plateau asalts, but their precise age, whether Early Pliocene or Miocene, :annot be determined. Their history, also, is a difficulty. The

* That is obvious with the MgO and CaO; and is, no doubt, true of the FeO, but in nost of the analyses all the iron present appears to have been estimated either as FeO ›r as Fe_2O_3, only the first one distinguishing them.

† These are so numerous that, in putting together these notes, I have not attempted o enter into the details of a locality, but have sought to enable the reader to lay hold of he main features of the district and its geology.

Time will be saved and reference to any local peculiarities facilitated by giving a translation of a table of the volcanic ejections, classified according to their geological age, in each of the great districts (*Livret Guide, Massif Central*, p. 15).

		Mézenc and Mégal.	Velay.	Cantal.	Mont-Dore.	Northern Chain of Puys
Quaternary.	Upper					Vents with craters, basalts, labradorites, and andesites
	Middle				Vents with well-preserved craters	
	Lower		Basalts of the slopes and beds of valleys		Basalts of the slopes	
Pliocene.	Upper		Basalts with tuffs (*Elephas meridionalis*) Scoria cones, more or less degraded	Plateau basalts	Plateau basalts	Plateau basalts *
	Middle	Sub-porphyritic basalts Phonolites	Basalt and breccias of Le Puy alternating with alluvial deposits (*Mastodon arvernensis*).	Upper phonolites Andesites, with hauyne (Breccias conglomerates and andesite cinerites)	Alluvial deposits (Perrier) Upper phonolites Andesites with hauyne (Breccias conglomerates & cinerites.)	
	Lower	Upper trachytes Andesites and augitic labradorites Porphyritic basalt		Porphyritic andesite of the peaks Porphyritic basalts and augite-andesites intercalated in breccias Porphyritic basalts, labradorites at base of breccias	Andesites and trachytes of the hills Basalts, labradorites, and andesites intercalated in breccias Porphyritic basalts	
Miocene.	Upper	Lower trachytes Lower basalts		Trachytes, and lower phonolites: Trachytic tuffs. Lower basalts	Trachytes and lower phonolites Rhyolites and acid cinerites Lower basalts?	Domites? †

* I have ventured to insert this on the table because the plateau basalts, according to the geological map in the *Livret Guide*, extend into this northern region, and can be seen in places capping the Tertiary deposits, and deeply gashed by the valleys down which the Upper Quaternary lava streams have descended.

† The exact position of the domites cannot be determined, but they are older than the plateau basalts.

rock is a somewhat decomposed variety of andesite,* but whether the masses represent the core of a volcano, laid bare by the removal of its pumiceous materials, or a shallow laccolite similarly exposed, or a pasty lava, which solidified as it welled up from an orifice, as suggested by Scrope, is uncertain. The Puy Chopine (Fig. 24) is riven by a sheet of basalt, and encloses in its upper part fragments of granite with the sedimentary rock into which that has intruded. According to Prof. Michel Lévy the upper part of the Puy de Dôme is a dyke-like mass intrusive in the rock forming the lower slopes. The Roman ruins on the summit, its connection with Pascal's barometric experiments, and its commanding view give an exceptional interest to the ascent of this mountain (4,806 feet). We look down on a broad zone of lava streams and craters, in every stage of preservation, some of these close at hand and the most perfect in

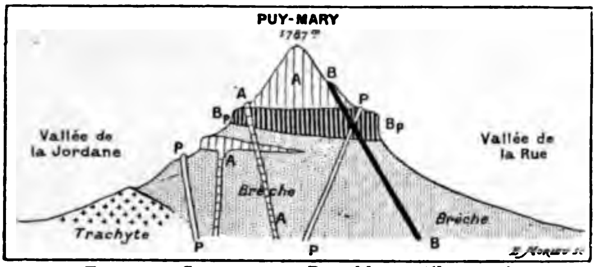


FIG. 23.—SECTION OF PUY-MARY (CANTAL).

A. Andesite. P. Phonolite.
B. Basalt. Bp. Porphyritic basalt.

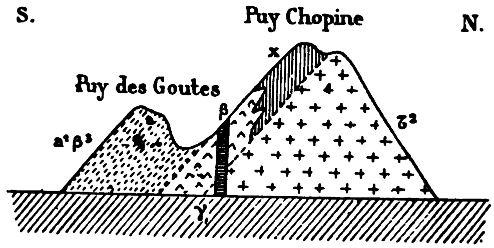
(Reproduced, with the permission of Messrs. Masson & Co., publishers, of Paris, from the *Guide to the Cantal*, by M. Boule and M. Fargès.)

Auvergne, such as the Nid de la Poule (on the flank of the Petit Puy de Dôme), the Puy Pariou, rising from the ruins of an older ring, and its great lava stream, the Puy de Louchadière, the Puy de las Solas, and the Puy de La Vache, side by side, with lava streams, which have welled up from their throats, and poured forth through their riven walls, to unite in the open country beyond. To the inner wall of the crater of the latter, curiously-formed masses of lava are still attached, which Scrope suggests may be indicative of the height to which the liquid rose before the cone was ruptured, but it occurred to me as possible that they might have been squirted up against the sides from the ebullient mass below. The lava streams themselves will repay examination, and loose crystals of augite and grains of olivine can be found among the dark scoria of the adjacent less perfect crater of the Puy Noir.

* The composition of the andesite of the Puy de Dôme is SiO_2 = 60.97, Al_2O_3 = 20.92 Fe_2O_3 = 3.81, MgO = 0.29, CaO = 0.14, Na_2O = 5.03, K_2O = 8.88, H_2O = 0.38, S.G. = 2.60. The soda in domite generally exceeds the potash, and in an analysis quoted by Rosenbusch (from the N.W. foot of the Puy de Dôme) the soda is 4.00 and the potash 3.64, but in this the SiO_2 rises to 68.78.

We may, however, leave details to the friendly conductors of the excursion, merely mentioning the basalt of the Plateau de la Prudelle, which, above the gorge of Villar, is seen to rest first on granite, then on marls, as well as the flows belonging to the latest set of discharges, from the Puy de Louchadière into the valley of the Sioule, and from the Puy de Gravenoire in the glen of the Tiretaine. Crater lakes are not abundant, but the Lac Chambon, Lac Savin, and Lac Chauvet are examples.

There can be no doubt that volcanic activity continued in this



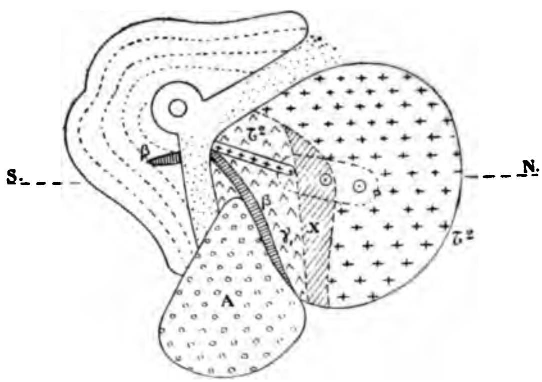


FIG. 24.—SECTION AND PLAN OF PUY CHOPINE.

γ Hornblende-granite. X Altered sedimentary rocks.
τ^2 Trachyte. β Basalt.
$a^1\beta^3$ Puy des Goutes (basaltic crater).

northern region to a late, probably a Post-Glacial, age. Sundry relics of man in a rock shelter beneath the lava stream from the Puy de Tartaret show, however, that as this flow is anterior to the "reindeer age" the eruptions may have ceased early in Palæolithic times. But it has been maintained that there was an isolated outburst so late as the fifth century of the present era. Such evidence as we can obtain is cited in the Geological Magazine for 1865,* and we are left with this alternative—either that a bishop

* By the writer. Vol. ii (1st Decade), p. 240.

of Clermont and an Archbishop of Vienne used language which would be bombastic even in ecclesiastical writings of that age, or that there were isolated volcanic outbursts, more probably at some place nearer Vienne.

The volcanic rocks of Auvergne afford excellent examples of various characteristic structures. The partially destroyed craters illustrate the mode of their building; specimens of scoria and volcanic bombs are often strewn on the plateau. The lava flows, as we have already said, frequently retain the original asperities of their surface. They may also be seen in places, especially in artificial sections, in contact with the rocks below, and sometimes (as at the time of my visit near Beaumont, on the Mont-Dore road) involving in their passage pieces of the underlying marl; but besides this, both in quarries and on natural crags, many of the larger structures can be studied with great advantage. Columns are common, some of the best examples being on the hill of Bonnevie, near Murat, and the Croix de Paille and Les Orgues d'Espaly, near Le Puy; so also is spheroidal structure, and I met with sundry cases which throw much light on that of cup and ball. Instances also of fissile, tabular, and the peculiar curved fractures, rudely resembling a watch glass in outline (Fig. 26), may also be seen, as at the section of the Prudelle plateau-basalt above Villar; but the Roche Tuillière and the Roche Sanadoire, two phonolite hills near the high road from Clermont Ferrand to Mont-Dore, are exceptionally interesting. In the former the large and rather rude columns are affected by a fissile structure (Fig. 27) which, as the name implies, causes them to be worked for roofing. It apparently traverses the whole mass in a series of concentric flattened curves, probably related to an exterior surface (Fig. 28). In the Roche Sanadoire both structures

FIG. 25.—SPHEROIDS IN AN UNJOINTED COLUMN, NEAR LE PUY.

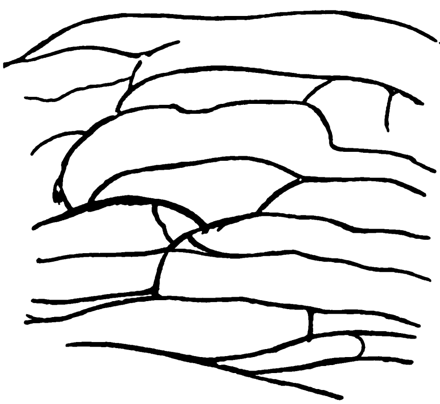


FIG. 26.—DIAGRAM OF STRUCTURE, PLATEAU DE LA PRUDELLE.

are present, but the columns are smaller, and in part of the hill apparently radiate from a centre, the fissile structure following its spheroidal surface, and the two, by alternately dominating, producing a peculiar "frilled" effect (Fig 29).*

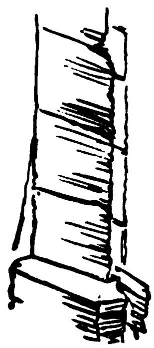


FIG. 27.—FISSILE STRUCTURE, ROCHE TUILLIÈRE.

Mineral springs are numerous in Auvergne. Those of Mont-Dore have been famous since Roman days; most of them issue at temperatures ranging from 102° F. to 113° F., one only being cold. They are alkaline, besides containing iron and arsenic. So also are those of St. Nectaire, which vary on either side of 100° F. Those of Royat (temperature about 50° F.) are also alkaline. In the public gardens one of them bubbles up in a basin, like a miniature Pool of Bethesda at the troubling of the waters. Those of Saint Allyre, near Clermont Ferrand, are also medicinal, but this place is chiefly noted for its petrifying springs. These deposit carbonate of lime in moulds, and even encrust the skins of birds, dogs, cows, and horses.† The stream, as it runs away from the *works*, has built up for itself a conduit of stalactitic tufa, and has even thrown an arch across the stream of the Tiretaine. St. Nectaire also has its calcareous springs, which are similarly made useful.‡ Mephitic vapours are emitted here and there; as, for instance, in a grotto under the lava stream of the Tiretaine valley, rather below Royat. The floor of this grotto is a little more than a yard below the level of the entrance. We can walk about without inconvenience, but if a scrap of burning paper is dropped from the hand it is silently extinguished on reaching the pool of carbonic acid gas, and we need only dip our heads to become conscious of the poison.

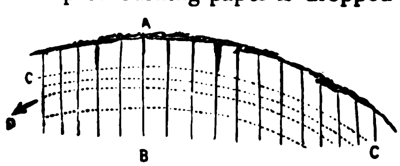


FIG. 28.—DIAGRAM OF ROCHE TUILLIÈRE.

AB. Vertical Joints.
CC. Direction of Fissile Structure.
D. Direction of Southern end of Cliff.

We may now offer a few remarks on the relation of the volcanic discharges of Auvergne to the mid-European earth movements. More than one set of folds and faults have affected the region, those of later date being no doubt modified by the results of the earlier. We must, however, restrict ourselves

* For a fuller description of these structures and their significance see a paper by the writer, *Quart. Journ. Geol. Soc.*, 1876, p. 140.

† At least they did in 1875, with results the reverse of beautiful.

‡ Sulphur has been deposited, as I remember to have seen on the Sancy, but the sofataric stage seems, strictly speaking, to have ended.

mer, since they are more immediately connected with the
outbreaks. The western half of the present Alpine chain
rise about the close of the Eocene, and apparently
ot less than its present elevation in the Miocene. This
ovements does not seem to have at first seriously
Auvergne, which, however, became by degrees sensible
essure; this was more intense during the second or
ely post-Miocene movements, when the Oberland, Savoy,
phiné regions were so profoundly affected, and the
rates formed at the margin of the earlier Alpine chain
mselves greatly elevated. During these movements
t crystalline mass of Auvergne must have acted
orst," though, as Prof. Michel Lévy describes, not

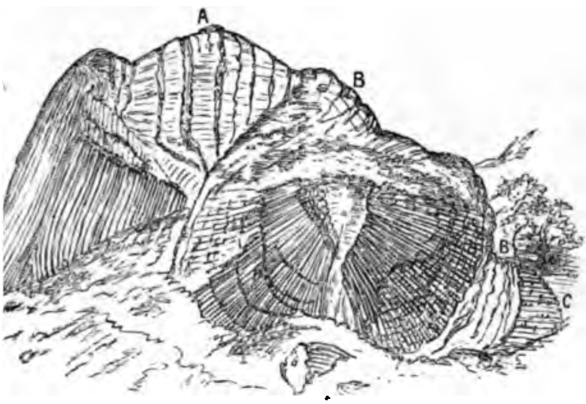


FIG. 29.—STRUCTURE OF ROCHE SANADOIRE.
AC. Jointed columns. B. Fissile band.

self suffering from the pressures. It was thrown into
and synclinal folds and severed by faults, and
aterial from beneath the more solid crust was squeezed
gh fissures thus formed. Those folds may be traced
Western Alps to Auvergne, running at first, as in the
oughly from N.N.E. to S.S.W. On approaching the
lateau their direction becomes more nearly N. and S.;
sometimes keeping nearly parallel with their axes, but
n, at any rate near the volcanic vents, taking a course
I.W. to S.S.E., or even somewhat to the west and east
In fact, more than one set of faults has been traced. The
canic district, as Prof. Michel Lévy tells us, lies within
triangular area, which is bounded on the west by a great
ning from a little E. of N. to W. of S., a second going
I. end towards the S.E., and the third side being formed
or band of small parallel W.N.W. to E.S.E. fractures.

Faults parallel to the last group occur in the region of the northern Puys, but the position of the vents is more immediately determined by the N. to S. disturbance, though the remainder of the volcanic groups, including Mont-Dore and the Cantal, appear to arrange themselves on sets of lines running N.N.W. to S.S.E. These faults cut the Oligocene beds in the Limagne (Fig. 31) and elsewhere, displacing them occasionally as much as 2,500 feet vertical. An examination of the tabular statement given above shows that very frequently similar magmas were simultaneously tapped, but the order of succession which it reveals is not that which is required by some theories of magmatic differentiation.

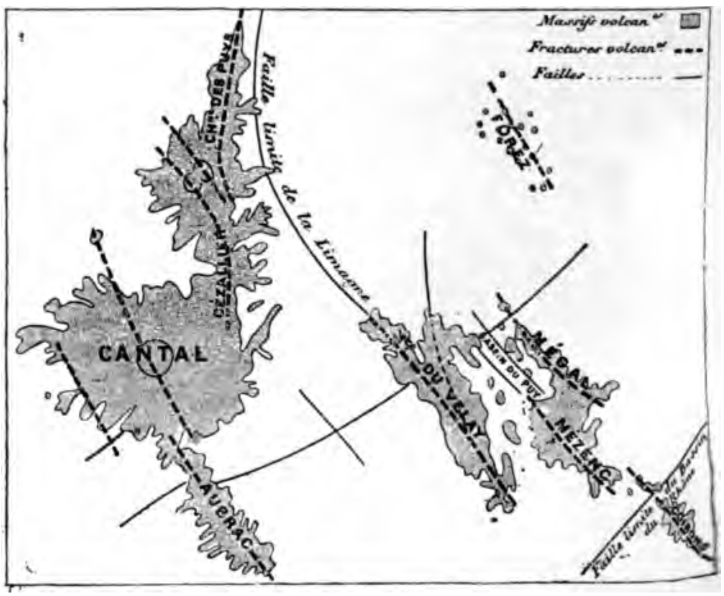


FIG. 30.—FRACTURES AND VOLCANIC MASSES OF CENTRAL FRANCE.

Glacial Deposits.—We must now refer to the traces of glacial action in the mountains of Auvergne. The latter, towards the close of the Pliocene period, had been carved by the elements almost into their present form. Deep valleys furrowed the flanks of the Cantal and Sancy, their craters had disappeared, steep cliffs gave in places a real grandeur to their summits. Then, as the temperature fell, snow gathered on their slopes, and glaciers formed in their glens. How far these descended may be still open to discussion; certain deposits, though containing some ice-borne materials, may be more immediately due to the action of water—"glacial schotter," to use the German term,—rather than ıines; but that glaciers once existed in Auvergne may be n as established. For this to be possible the mean tempera- must have been at least 16°F. to 18°F. lower than at the ent day.

Conclusion.—All these changes, the building and destroying of sedimentary deposits and of volcanic hills, have happened the end of the Eocene period. Nearly all the former, and whole of the latter are more recent than any of the iary strata of the Isle of Wight. When the Scottish volcanoes dying, those of Auvergne began to live. The history which one commences the other completes. Yet here, even since niddle of the Pliocene period, volcanic cones, rivalling Etna titude, have been built up, and then deprived of their craters, ıed with valleys, and carved into crags.* (Fig 17). The bulk of sediments have been removed from the old lake basins, and ıeir ancient shores deep ravines have been excavated, as the s have again worked their channels down to their original

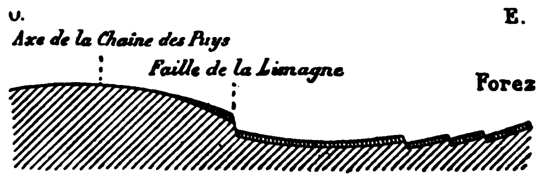


FIG. 31.—THE LINE OF NORTHERN PUYS AND THE LIMAGNE FAULT.

ls. In looking at the Pliocene strata of our Eastern nties we can hardly realize that since this period began, thern England has mainly assumed its present contours of hill valley; that the Weald of Kent and Sussex, and the valley of the er Thames are mostly post-Miocene features: that even Palæo- man could cross dryfoot from England to France, or by fording er could walk from Hampshire to the present Isle of Wight. iary, and especially the later Tertiary, deposits are compara- y so insignificant in the British Isles that we are apt to forget era was probably almost as long as the Secondary, and essed changes, physical and palæontological, perhaps even important. The great crust movement, which first gave birth he Alps, seems to have produced no more than a general eaval in our islands; the second one, which enlarged their and stimulated the Auvergne volcanoes to fiercer action, has a slightly stronger mark in the uplift of the Weald and the ression of the Thames valley. That one sharp fold in the of Wight is perhaps the only striking sign in our island of the

* Even now the summit of Sancy is 6,187 feet above the sea-level, and that of the b du Cantal 6,096 feet.

forces then at work in Central Europe. Thus, we must not be too ready to measure other lands by standards taken from our own, or to think that because its history was uneventful there were not days of storm and stress elsewhere. These lessons, perhaps, are not the least of the many which we can learn from a visit to Auvergne.

For the use of figures 25—29 we have to thank the Council of the Geological Society. All the rest are from Parts X. and XIV. of the Livret Guide of the International Geological Congress for 1900. For some of these we are indebted to M. Michel Lévy, for others to M. Boule, and we have to thank them for so readily granting, through the kind intervention of Prof. C. Barrois, editor of the "Livret Guide," our application for clichés and for the great trouble they have taken to supply them for use in this article. It is perhaps needless to add that when the original legend formed part of the block it has had to remain without translation.

The following list of books is given in the "Livret Guide, Massif Central" (p. 35) : —

POULETT-SCROPE.—The Geology and Extinct Volcanoes of Central France, 2nd Ed., 1858.

FOUQUÉ.—Le Plateau Central de la France (Académie des Sciences. Comptes rendus) 1890.

BOULE (M.)—Le Massif Central de la France (Ext. du *Dictionnaire Géographique de la France* de Joanne) 1895.

MICHEL LÉVY.—La Chaine des Puys et le Mont Dore (*Bull. de la Soc. Géolog. de France*, 3me Sér. t. xviii., pp. 688-845)—Réunion de la Société Géologique de France à Clermont Ferrand en 1890 (*id.* pp. 678-953).

BOULE (M.)—La Topographie glaciare en Auvergne (*Annal. de Géogr.* 1896).

RAMES (J. B.)—Géogénie du Cantal, 1873—Réunion de la Société Géologique de France à Aurillac en 1884 (*Bull de la Soc. Géol. de France*, 3me Sér. t. xii., pp. 773-828).

BOULE (M.)—Le Cantal Miocène (*Bull. des Services ae la Carte Géol. de France*, No. 54, 1896).

BOULE (M.) et FARGES (L.)—Le Cantal, Guide du Touriste, du Naturaliste, et de l'Archéologue, 1898.

BOULE (M.)—Géologie des Environs d'Aurillac (*Bull. des Services de la Carte Géol. de France*, No 76, 1900).

The places which may be visited on the excursion are on the following sheets of the Carte Géologique de France (1. 80,000). No. 166. (Clermont). 175. (Brioude). 184. (Aurillac), 185. (St. Flour).

THE POST-PLIOCENE NON-MARINE MOLLUSCA OF THE SOUTH OF ENGLAND.

By A. S. KENNARD and B. B. WOODWARD, F.L.S., Etc.,
With a Note by Dr. H. P. Blackmore, F.G.S., Etc.

[*Read March 1st, 1901.*]

A.—INTRODUCTION.

THIS communication is a further instalment of an attempt to place on a more satisfactory basis our knowledge of the geological history of the non-marine Mollusca of this country. It is obvious that if this is done great light will be thrown, not only on geological problems, but also on some of the many vexed questions of geographical distribution.

It is, of course, impossible to attempt such a task as we have set ourselves without the aid of numerous friends, and in this respect we have indeed been favoured, and would take this opportunity of thanking those gentlemen who have so greatly and so kindly aided us, either by permitting the free examination of specimens under their care, or by forwarding material for inspection, or in numerous other ways. Those friends to whom we are so indebted are Dr. Henry Woodward, Professor T. Rupert Jones, Dr. Frank Corner, the Rev. R. Ashington Bullen, H. A. Allen, W. J. Lewis Abbott, F. J. Bennett, F. Chapman, R. Miller Christy, Dr. W. H Dall, E. Dixon, R. Elliott, Benjamin Harrison, M. A. C. Hinton, G. Holbrook, J. P. Johnson, J. T. Kemp, A. Loydell, the late C. J. A. Mëyer E. T. Newton, W. M. Newton, R. Bullen Newton, H. M Platnauer, R. Nuttall, E. P. Richards, Clement Reid, F. C. J. Spurrell, H. Stopes, D. Taylor, W. A. E. Ussher, and G. White, whilst to Dr. H. P. Blackmore we are indebted for the account of the Holocene deposit at Dewlish. Dr. O. Boettger, of Frankfort, has also rendered us invaluable assistance in determining doubtful examples.

We would, however, appeal to the members of this Association for further help. An examination of the localities recorded in this paper shows that the majority are in the county of Kent—in other words, in that part of England which has been most visited by London geologists. There must be numerous other Pleistocene and Holocene deposits in other counties which still await the notice and the pick of the geologist.

The district dealt with in the present paper is that lying south of the Thames, and thus includes Kent, Surrey, Sussex, Hampshire, Isle of Wight, Wiltshire, Berkshire, Somersetshire, Devon and Cornwall. The Holocene deposits are taken first, and then the Pleistocene. In each case the order adopted is to begin with the Thames Valley, treating of the several localities as nearly as possible in the order of their occurrence, proceeding from west to east, and then to deal with the valleys to the south and west, taking them in reverse order, viz., from east to west.

Four out of these localities have been touched upon in a former paper, but further facts have come to light since then.

The method of procedure adopted, when dealing with published lists of specimens that have since been lost, is to include the several species on the authority of the first recorder, unless there is any doubt as to the correctness of record. In the subjoined table will be found a complete summary of the distribution of the various species. In the first column is a complete list of the known species of British non-marine Mollusca, the names of the species extinct in this country being in ordinary type; in the second column those occurring in the south of England are noted; whilst the various fossil records follow in successive columns under the several more important localities. Minor occurrences are grouped together under Holocene and Pleistocene respectively. Finally, in the last column are recorded those species which have been found in the Pliocene beds of England.* A complete bibliography has also been appended.

B.—NOMENCLATURE.

This not being a systematic paper and the identity of the shell being of more importance just now than the absolute correctness from a "priority" point of view of the name which it is to bear, we have endeavoured to avoid alterations in the nomenclature as much as possible.

Undoubtedly, further changes will have, sooner or later, to be made if the rules of zoological nomenclature are to be adhered to; but these rules, having been founded with the object, as far as possible, of preventing confusion, will, however, we venture to think, be better kept on the present occasion by their breach rather than by their observance.

We have, nevertheless, had to accept *Pomatias reflexus* (Linn.) in lieu of *Cyclostoma elegans*, Müll., and *Paludestrina stagnalis* (Bast.) in place of *Hydrobia ulvæ*, Penn.

The greater number of innovations are, however, due to increase of knowledge concerning classification. Thus the great group *Helix* has been split up by Pilsbry and others into separate genera, while *Vertigo edentula* has been removed to the Endodontidæ, and as *Sphyradium edentulum* ranks next to *Punctum pygmæum*.

* The Forest Bed being now generally held to belong to the Pleistocene period, reference to species occurring therein is omitted from this column.

A conspicuous alteration due in part to priority and in part to ıtomical investigation, is the substitution of *Helicella barbara* nn.) for the time-honoured *Bulimus acutus*, Müll.

Other transmutations are due to errors of identification, viz.: *gromia granulata*, Alder, is not, as had been supposed, the *lix sericea*, Drap.; *Cochlicopa lubrica*, Müll., is not the *Helix cylindracea*, Linn.; nor is *Planorbis glaber*, Jeff., identical with *parvus*, Say, as we have had previous occasion to point out.

Vitrea glabra, we have been constrained to leave as of "Brit. ıct.," since it has still to be satisfactorily identified, or named. is certainly not the *Vitrea glabra* (Stud.) Charp., and differs nsiderably from the *V. Helvetica*, Bourg.

C.—HOLOCENE DEPOSITS.

1. Newbury.

The first published notice of the Mollusca from the Kennett lley deposits at Newbury was in 1854 (9), when Professor T. pert Jones recorded fifty-one species on the authority of Mr. Pickering. In 1856, Mr. S. V. Wood noted forty-five species), none of which were new, the printer, perhaps, being respon- e for the omission of the rest. The first list was copied with a alterations in nomenclature in 1872, in the Geological Survey moir (31). In 1883, one of us pointed out that the examples of *ix aspersa*, recorded from the Newbury marl, were probably of e recent date, since the numerous pits which from time to time e been dug in the peat quickly fill up (*Science Gossip*, 1883, I 15, 237), and Dr. Frank Corner informs us that Saxon ains have been found at a depth of 10 feet in the peat; whilst 897, an account of the Mollusca was given by us as an appen- to a paper by Mr. E. Percy Richards (65). Of existing nples there is a series at the Natural History Museum, which been presented by Mr. Pickering to this Association, and sferred by them to the national collection. This has been lemented from a series in our own possession. We are thus led to compile a list of forty-four species, nine of which have previously been recorded. We have considered it advisable ject five records as being, in all probability, errors in identi- ion. These are, *Limax carinatus* [= *Amalia sowerbyi*], *tes* [= *Vitrea*] *alliarius*, *Helix hortensis*, *Helix* [= *Helicella*] *ata* and *Vertigo alpestris*. Two of Mr. Pickering's species now considered as only varieties of other forms. We e hitherto rejected *Helix aspersa*, but on further sideration we have decided to include it on the authority of Pickering. As we have already seen, it has been found in an undisturbed Neolithic deposit at Greenhithe, and it has also been found in the Lea Valley (*Essex Naturalist*, 1897, Vol. X., p. 92). The new records are :—

Vitrea nitida,	*Vertigo antivertigo*,
Arion ater,	*Planorbis glaber*,
Helicella itala,	*Physa hypnorum*,
Helicigona lapicida,	*Pisidium milium*,
	" *nitidum*.

Nine other species we have tabulated on the authority of Mr. Pickering, thus bringing the total up to fifty-two. Of the new records, by far the most interesting is *Pisidium milium*. It has been found in the Forest Bed and in the Pleistocene of Ilford, but has hitherto been unknown from any deposit of later age.

At the present day it is a local form, though widely distributed throughout England and Scotland and even met with in the Orkneys. In Wales it is only known from Anglesey, and in Ireland it has been noted from Galway. It is, of course, very improbable that so widely distributed a form should be a modern addition to our fauna, and its occurrence in the Newbury deposit is a welcome proof of this view.

Planorbis glaber is an extremely rare form in Holocene deposits, having only been found at Westminster, though it is a common Pleistocene species.

In studying the shells from this locality we have realised how necessary it is, in order to obtain an accurate idea of the fauna of any alluvial deposit, not only to have a large quantity of material, but also to obtain it from as many sections as possible. Our collection was derived from three sources. Firstly, a series collected by one of us during an excursion of this Association to Newbury in 1879; secondly some specimens sent by Mr. F. J. Bennett; and, lastly, a large quantity of material forwarded by Mr. E. Percy Richards. From each of these a different series of species was obtained. In the first supply *Helix nemoralis*, *Helicella itala* and *Bithynia tentaculata* occurred, though not forthcoming from the other two sources. Numerous examples of *Valvata piscinalis* were amongst Mr. Bennett's samples, and these are the only specimens we have seen.

The material which Mr. Richards sent us was obviously from the site of a swamp or marsh as shown by the abundance of *Agriolimax agrestis*, *Arion ater*, *Vertigo antivertigo*, *Carychium minimum*, and *Limnæa truncatula*, forms which are all characteristic of marshy ground.

2. Kew

The Mollusca from the alluvium of the Thames at Kew were listed in 1890 (49). The species are twelve in number, viz. :—

Vitrea nitidula,	*Cochlicopa lubrica,*
,, *nitida,*	*Succinea putris,*
Pyramidula rotundata,	*Limnæa truncatula,*
Hygromia hispida,	*Planorbis carinatus,*
Vallonia pulchella,	,, *spirorbis,*
Helicigona arbustorum,	*Bithynia tentaculata.*

Amongst the examples of *Planorbis carinatus* is a keel-less example similar to those from the alluvium at Westminster, and which we have not met with from any other localities.*

3. Blackfriars.

An account of this deposit, with a list of the shells, was originally given in 1863 (21), and the list was revised by one of us in 1890 (49). No additional material has come to hand; consequently there is no alteration in the list which is set out in the table.

4. Ladywell, Lewisham.

We are indebted to Mr. E. Dixon for a knowledge of the only examples of shells we have seen from the alluvium of the Ravensbourne, and he very kindly placed the collection at our disposal. The shells were found during excavations made at the Recreation Ground, and bones of deer, horse, and ox were discovered with them. The species are ten in number, and call for no extended observation beyond noticing that the examples of *Pisidium amnicum* are extremely fine. The species are as follows:—

Hygromia hispida,	*Bithynia leachii,*
Cochlicopa lubrica,	*Valvata piscinalis,*
Succinea putris,	*Neritina fluviatilis,*
Limnæa pereger,	*Anodonta cygnæa,*
Bithynia tentaculata,	*Pisidium amnicum.*

The shells are probably not of great antiquity, but are almost certainly pre-Roman.

5. Charlton and Crossness.

The Mollusca from the Crossness deposit have already been described in the Proceedings of this Association (49), and we have nothing further to add. Dr. Frank Corner has placed at our disposal a small series of shells found in 1895 at Charlton, in "clay, above deep ballast, between two beds of peat, some 30 to 40 feet from surface." The species are 12 in number, viz.:—

* See note by us, written since this paper, in *Proc. Malac. Soc.*, Lond., vol. iv, p. 236.

Vitrea cellaria,	*Planorbis fontanus,*
„ *nitida,*	*Succinea putris,*
Pyramidula rotundata,	„ *elegans,*
Helicigona arbustorum,	*Limnæa pereger,*
Cochlicopa lubrica,	„ *palustris,*
Clausilia bidentata,	„ *truncatula.*

With the exception of *Succinea putris*, all these forms occur at Crossness, and we have, therefore, tabulated them together, but the Charlton shells are without doubt very much older than the Crossness ones. In *British Conchology* (vol. i, p. 65) it is noted by Dr. Gwyn Jeffreys that *Paludestrina confusa* (=*Hyrobia similis*, Drap. of Jeffreys' *non* Drap., see E. A. Smith, *Jour. of Conch.*, vol. vi, 1890, p. 245) had been found by Mr. Prestwich and Mr. Pickering in peat, in the main drainage cutting between Woolwich Arsenal and Crossness. We have been unable to trace Mr. Pickering's collection, and there are no specimens of this shell in the Prestwich collection now in the Natural History Museum. There being, however, no reason to doubt this record, we have listed it on the authority of Mr. Pickering (71).

6. Seal.

In a meadow on the east side of Watery Lane, and about a mile from the village of Seal, near Sevenoaks, is a modern alluvial deposit. Probably at one time a mill stood there, as there is a mill dam at the eastern end of the field, and a paved causeway may be traced leading from it. No trace of the deposit is to be seen in the small stream running through the field, and in all probability it is the deposit of a mill pond. Unfortunately there is no section, but one of us has obtained a few species of shells from the mole-hills, and these have been supplemented by examples presented to us by Mr. W. J. Lewis Abbott, who first called our attention to the deposit. There are eleven species represented, viz.:

Agriolimax agrestis,	*Succinea putris,*
Vitrea nitidula,	„ *elegans,*
Hygromia hispida,	*Limnæa pereger,*
Vallonia pulchella,	*Bithynia tentaculata,*
Cochlicopa lubrica,	*Valvata cristata,*

Vertigo pygmæa.

Since these shells are so recent they call for no remark.

7. Exedown (near Wrotham).

This deposit is situate on the face of the Chalk escarpment just below the summit, and is exposed in a road cutting and in a trench made under the direction of a committee of the British

Association in 1894 appointed "to investigate the nature and probable age of the high level flint drift on the face of the chalk escarpment near Ightham, which appears to be productive of flakes and other forms of flint, probably wrought by the hand of man." * In the report it is stated that "This patch of gravel has been preserved upon a promontory of the chalk escarpment at an altitude of 658 feet O.D. It extends for some 70 yards and attains a maximum thickness of 5½ feet. It is composed chiefly of sharp, angular flint, varying in colour from bluish-white to bleached white. Accompanying this is a quantity of deeply-stained ochreous flints, with here and there pieces of chert, Oldbury stone, and rag. Flakes made by man exist in thousands, and they preponderate over the more elaborately-worked specimens. No perfect large tools nor any with traces of polishing were found. The matrix is usually clayey, of a dark red colour, but in places it is quite chalky and unstratified. A large quantity of the flints are encrusted with carbonate of lime." As too often is the case, the shells were not noticed when the trench was dug, their presence being first detected by Dr. Frank Corner, who kindly informed us, since when the section has been worked by one of us. The lowest part of the deposit is seen to be practically a rainwash, with only few flints, but as one ascends the hill it is found to become more and more stony. The shells occur principally towards the base, and are most abundant at the lowest part, varying inversely to the flints.

The deposit is overlain by black soil containing fragments of bricks, or by refuse from an adjacent chalk quarry now deserted. Besides the worked flints the only trace of man was a small fragment of Neolithic pottery. As to the age of this deposit it is extremely difficult to speak with certainty. There can be no doubt that the worked flints were bleached before they were deposited, hence the shells must be very much newer. The deposit practically constituting the top soil, there is also the strong probability that the presence of one or two species may be accounted for by burrowing for hibernation. As far, however, as it is possible to judge, the deposit is older than the rainwash at Otford, and is of pre-Roman age. The species are thirty in number, all being land Mollusca.

Of great interest is the occurrence of a single example of *Helicella virgata*, hitherto unknown from the Holocene of the home counties with the exception of Faversham. The specimen is a dwarfed form. The presence of *Helicella cantiana* is discussed later. *Balea perversa* is an extremely rare form in the fossil state since it has hitherto only been known from the Pleistocene of Barnwell, and the Holocene of Crossness, Kent, though it has been recorded from Maidstone. The calcareous granules representing the shell of *Arion ater* are not uncommon, whilst

* *Brit. Assoc. Report*, 1895 (Ipswich), p. 349.

some, from their larger size, are most probably those of *H. hortensis.*

The band formulæ of the examples of *Helix nemoralis* pre are :

12345 ...	4 examples	(123)(45) ...	1 example
00345 ...	1 example	123(45) ...	1 „

Those of *Helix hortensis* are :

00000 ...	2 examples	12345 ...	3 examples

8. Otford.

For a knowledge of this deposit we are indebted to Mr. J. Lewis Abbott, who incidentally mentioned its occurrence a the number of species found there in his paper, on "The ossifer fissures in the valley of the Shode near Ightham" (54). It w visited by members of this Association, during the excursi to the Holmesdale Valley, on September 18th, 1897, under t guidance of one of us, when its principal features were poin out and its probable age discussed. The deposit is w exposed in the disused chalk pit adjoining Otford Station; b here, however, it has undoubtedly been disturbed during t quarrying operations. Its probable thickness is about two fe the upper part in the quarry (where it apparently attains thickness of six feet) being in all probability the refuse of t workings. A similar bed is to be seen in the road cuttir between Otford and Kemsing, and in the various chalk pits the foot of the escarpment. It is purely a rainwash, being t sweepings of the hills above. The wide extent and uniformity the bed clearly show that there was no woodland growth on t slopes of the Chalk hills during its formation, and it probably w caused by the destruction of the forest, thus exposing the disin grated soil to the mercy of every shower. It is certainly pc Roman in its age, as one of us found a Roman bronze pin the very base of the deposit and resting on the chalk. Otl Roman remains and Neolithic implements also occur scatter throughout. The shells are extremely abundant, and we are al to record twenty-eight species from the collection in c possession, supplemented by Mr. Abbott's examples. Thou this deposit is quite a modern one, yet, on comparing the for with those now existing in the district, a difference will be notic *Helicella virgata* is at present the most abundant form, living countless myriads on the downs above, yet it is absent fr the deposit; so, too, is *Helix hortensis*. *Helix pomatia*, anot resident, is also unrepresented in the deposit. On the ot hand, *Helicella cartusiana*, now extinct in the district, represented by a single example. The occurrence of a si specimen of *Succinea putris* is noteworthy, a dry chalk hill being an uncommon habitat for this semi-aquatic species.

s granules representing the internal shell of *Arion ater* non, and so, too, is *Cæcilianella acicula*; but since this n is subterranean in its habits, it may not truly belong posit. *Helicella cantiana* is scarce, and nearly all the are immature. The band formulæ of the specimens of *noralis* present are :—

·00,	9 specimens	1 (23) (45),	2 specimens
;00,	1 specimen	12345,	6 ,,
;45,	1 ,,	12345,	8 ,,
45),	1 ,,		

ples of the bandless specimens are the brown form, bably represents the complete coalescence of the bands. also four examples with translucent bands.

9. Darenth.

Mollusca from the rainwash immediately above the well-oman remains at Darenth were described by one of us (59), and a comparison made between the molluscan the deposit and that now living in the neighbourhood. n additional material has come to hand, but we are only add one species, *Helix pomatia*. This is of great ce, as showing that it existed here during the period ely subsequent to the Roman occupation. There is one to make in the published list; *Amalia sowerbii* should *imax agrestis*. This deposit being of the same age as bouring one at Otford, they have been put together in

10. Greenhithe.

cquaintanceship with the hillwash at Greenhithe we have Dr. Frank Corner, who kindly sent us a small series from that place. From his description of the deposit uded that it was of great interest, and one of us has eral visits to the section, and a large collection of the been made. The deposit may be traced overlying the tween Greenhithe and Northfleet, on the river side of s. Practically the whole of the Chalk adjoining the s been quarried away, and only a low bank separates om the marsh.

gh a careful examination was made, molluscan remains y found in one spot, in Messrs. Bazley White's pit, the cricket ground at Greenhithe. Here two sections e seen, one being parallel with the river and the other at es to it. The former showed about 3 feet of rainwash marsh clay, the latter containing no shells, whilst they y common in the overlying bed. The second section was of more interest, and is here given. In the southern part the wash rests on the Chalk, and shells are but few. The deposit is a chalky loam, containing small rolled fragments of chalk, large unrolled flints, a few Tertiary pebbles, and a large quantity of Neolithic flakes. Two fragments of pottery were found, which are either of Neolithic or of Bronze age. A few calcined pebbles also occurred. The shells were most abundant where the wash passed into the marsh clay. The spot is now distant about 300 yards from the river. The deposit is undoubtedly pre-Roman, and prior in age to the reclaiming of the adjoining marsh. We are able to show in the table thirty-four species, all of which are in our possession.

Of these, *Alexia myosotis* has hitherto been unrecorded from

Scale 1-24.

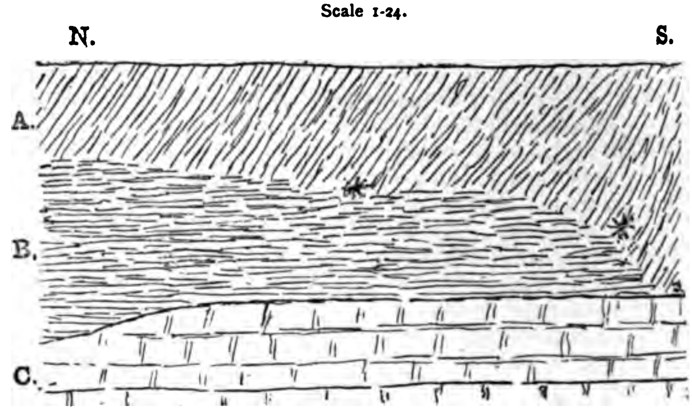


FIG. 32.—SECTION OF RAINWASH AT GREENHITHE, KENT.

A Rainwash passing down into (B) marsh clay.
C Chalk with flints.
* Fragments of Neolithic or Bronze age pottery.

any deposit in the Thames Valley, though it is abundant in the living state below Erith. *Helicella cartusiana* is fairly common, and, judging from the large size of the examples, was by no means dying out. *Helix aspersa* is not uncommon. One example was found, in company with the only examples of *Helicigona arbustorum*, in the marsh clay. The band formulæ of the specimens of *Helix nemoralis* are:—

00000,	8	specimens	(123)(45),	6	specimens
00300,	9	,,	123(45),	6	,,
12345,	20	,,	12045,	1	specimen
120(45),	2	,,	023(45),	1	,,
(12345),	4	,,	123(45),	1	,,

11. East Farleigh.

This deposit is situate on the left bank of the River Medway, between Tovil and East Farleigh, and extends a distance of about half a mile. It is by far the most recent bed we have examined, and in all probability it has accumulated during the last two centuries by the repeated overflowing of the river. The species are twenty-seven in number, and do not call for extended notice since they are all living in the district at the present time, the majority being, of course, aquatic forms. The occurrence of *Vitrina pellucida* is, however, noteworthy, this species being extremely rare, in the fossil state, in this country, though it certainly existed here in early Pleistocene times.

The species represented are :—

Vitrina pellucida,
Vitrea cellaria,
,, *nitidula,*
,, *pura,*
Arion ater,
Pyramidula rotundata,
Helicella cantiana,
Hygromia rufescens,
Vallonia pulchella,
Helix aspersa,
,, *hortensis,*
Cochlicopa lubrica,
Succinea putris,
,, *elegans,*
Ancylus fluviatilis,
Limnæa pereger,
,, *truncatula,*
Bithynia tentaculata,
,, *leachii,*
Vivipara vivapara,
Valvata piscinalis,
Neritina fluviatilis,
Anodonta cygnæa,
Sphærium rivicola,
,, *corneum,*
Pisidium amnicum,
,, *fontinale.*

Since these examples are so modern they are not inserted in the list.

12. Maidstone.

The first notice of the occurrence of Mollusca in the alluvium at Maidstone was in 1836 by Prof. John Morris (3). He stated that the Medway was a much smaller stream than it had formerly been, and in support of this he adduced the fact that shells had been found at Springfield Paper Mills whilst excavating for a reservoir. They were found in loamy sand, reposing on a bed of gravel, 10 yards from the river, and about 4 feet above its level. He noted that the shells had mostly lost their colour, those of the limaces were very abundant and frequently rounded like grains of pisolite, and added, as a singular occurrence, that all were land shells.

The names of seventeen species are given. In 1856, Mr. S. V. Wood (14) listed eighteen species on the authority of Dr. S. P. Woodward, seven species being new records, but six names which appeared in the first list were omitted. In a MS. by Dr. S. Woodward, possessed by one of us, twenty-two species are giv as having been found. There are no known examples from th locality, so the list cannot now be checked. *Succinea oblon* occurs in all three lists, but in all probability it is an error f *Succinea elegans.* The following is the list of species which ha been recorded :—

Agriolimax agrestis,
Amalia sowerbii,
Vitrea crystallina,
„ *cellaria,*
„ *nitidula,*
„ *pura,**
„ *radiatula,*
„ *fulva,*
Arion ater,
Pyramidula rotundata,
Hygromia hispida,
„ *rufescens,**
Vallonia pulchella,
Helicigona arbustorum,
Helix nemoralis,
„ *hortensis,**
Cochlicopa lubrica,
Pupa muscorum,
Vertigo pygmæa,
Balea perversa,
Succinea putris,
„ *elegans,*
Carychium minimum,
Limnæa truncatula,
Pomatias reflexus.

13. Charing.

At Charing, four miles north-west of Ashford, there is a foss ferous Holocene deposit of which we have no particulars, tho judging by the molluscan remains, it is without doubt a hill-w with an admixture of aquatic forms. In a MS. by Dr. S. Woodward is a list of fifteen species, noted as occurring h whilst of existing examples there is a small collection at Natural History Museum, and other specimens are in the pos sion of one of us and of Professor J. Rupert Jones. From th examples we are able to list nineteen species, whilst three recorded on the authority of Dr. S. P. Woodward. Of co nothing definite can be said as to the age of this deposit, b is probable that it will be found to be of Neolithic age.

14. Faversham.

From the above locality we have seen examples of sh which probably came from a Holocene deposit of which we h been unable to trace any published record. In a MS. Dr. S. P. Woodward is a list of thirteen species, apparently the authority of Mr. J. Trimmer. In the Geological Soci Museum are eleven species, whilst there is one species re sented in the Natural History Museum. From these specin

* On the authority of Professor John Morris; or the remainder, Dr. S. P. Woo is held responsible. It is, of course, quite impossible to say anything about the these shells, but seemingly they belong to the same period as the East Farleigh ex which we have already described, both deposits occurring at the same level.

e are able to check nine names in the MS., whilst *Planorbis* *rtex* is probably an error for *Planorbis spirorbis*, which latter ecies is at Burlington House. *Helicella cartusiana* is given ith a query, and no examples are known. It has been found in e hill washes at Greenhithe, Exedown, and Otford, so there is no herent improbability in the record. Since, however, *Helicella* *ntiana* is recorded from this locality by Mr. S. V. Wood (14), is quite possible there has been a confusion, and so it is better omit it. The remaining form, *Unio pictorum*, we have listed n the authority of Dr. S. P. Woodward.

The species are :—

Helicella virgata,	*Planorbis spirorbis*,
Hygromia hispida,	*Bithynia tentaculata*,
Succinea putris,	*Valvata piscinalis*,
Limnæa palustris,	*Unio pictorum*,
,, *pereger*,	*Sphærium rivicola*,
Planorbis marginatus,	*Pisidium amnicum*.

15. Pegwell Bay.

In 1893 Mr. Alfred Bell stated that a marine deposit existed Pegwell Bay, resting in a hollow on the summit of the chalk ff. From the brickyard he obtained *Hydrobia ulvæ* [= *Palu-trina stagnalis*] and other marine shells, while with them, ecially on the cliff face, were a number of land shells which ght have been introduced by a small stream ; he recorded nty-one species (52). The deposit is without doubt a marine of Pleistocene age, and a recent visit yielded only *Macoma thica* (Linn.), but several species of Foraminifera have been orded by H. W. Burrows and R. Holland.* We have been ble to trace Mr. Bell's specimens, but they are certainly not istocene, and are probably very modern. The species orded are :—

Limax maximus,	*Helix aspersa*,
Vitrea crystallina,	,, *nemoralis*,
,, *alliaria*,	*Buliminus obscurus*,
,, *cellaria*,	*Cochlicopa lubrica*.
,, *nitidula*,	*Cæcilianella acicula*,
Pyramidula rotundata,	*Pupa muscorum*,
Helicella virgata,	*Clausilia bidentata*,
,, *caperata*,	*Planorbis spirorbis*,
,, *cantiana*,	*Vivipara*,
Hygromia hispida,	*Pisidium nitidum*.
Vallonia pulchella,	

It will at once be seen that it is extremely unlikely that such series should occur in a Pleistocene marine bed containing rthern Foraminifera ; hence it is better to ignore the records.

* *Proc. Geol. Assoc.*, vol. xv (1897), pp. 19-52.

We may state that at the mouth of the Stour one of us has found in a post-Roman deposit *Paludestrina stagnalis* and *Limnæa pereger* with marine shells.

16. Buckland, near Dover.

In 1898 the Rev. R. Ashington Bullen recorded the Mollusca and described the sections at this locality (66). He considers that these deposits represent four distinct stages. Pleistocene, Neolithic, post-Roman and modern, and the shells are listed from each. The Pleistocene will be dealt with later. The species of Neolithic age are nineteen in number, and are set out in the table. The presence of *Helicella cartusiana* and *Helix aspersa* are noteworthy. Only two species were found in the post-Roman layer, viz., *Helicella cantiana* and *Helix aspersa*. It is worthy of note that the former species does not occur in the Neolithic layer.

In the top soil *Helicella virgata* is the only form: it is absent from the earlier beds, and therefore, in all probability, is quite a modern migrator into the district.

17. Folkestone.

We are indebted to the Rev. R. Ashington Bullen for a small series of shells from this locality. The specimens in question, with a large series of raised beach shells, were purchased recently at Stevens's auction rooms, and with them was a label "out of the Chalk Marl under the cliff, Folkestone, H.E. 1826." Two species are represented, *Helix aspersa*, *Pomatias reflexus*.

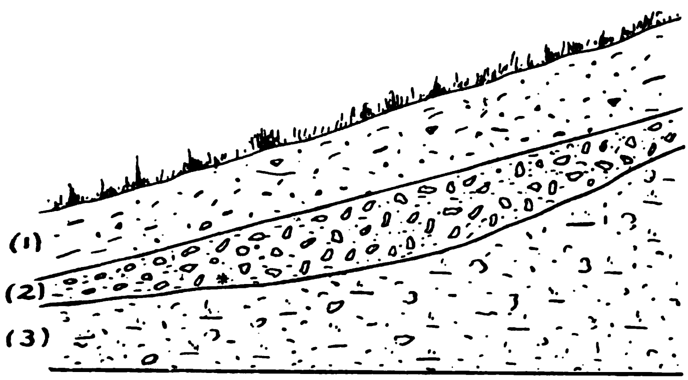
The shells still retain in their interior some of the deposi from which they were obtained, and there can be little doubt that they are from a rainwash or talus of no great age.

18. Eastbourne.

At Eastbourne the Wish deposited a series of alluvial beds, containing molluscan and vertebrate remains. The beds were described and the contained fossils were listed in 1873, by the Rev. E. S. Dewick (31A), the sections having been exposed in the excavations for the foundation of the baths at the corner of the Carlyle Road. Fifteen species of Mollusca were recorded, viz.:—

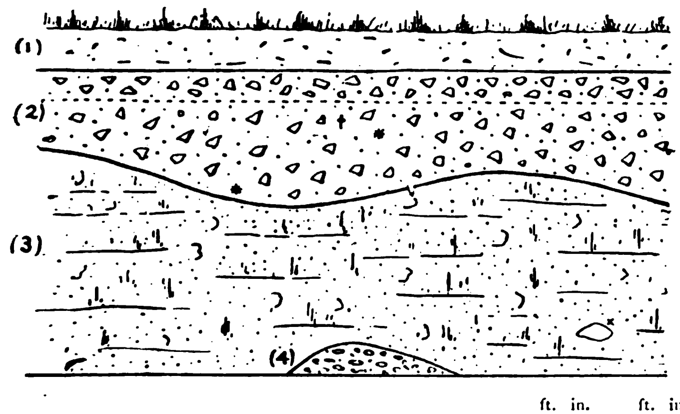
Vitrea nitidula,	*Valvata cristata*,
Hygromia hispida,	*Planorbis nautileus*,
,, *rufescens*,	,, *albus*,
Helix nemoralis,	,, *spirorbis*,
Succinea putris,	*Sphærium corneum*,
Limnæa pereger,	*Pisidium amnicum*,
,, *truncatula*,	,, *fontinale*.
,, *glabra*,	

FIG. 33.
SECTION AT BUCKLAND, NEAR DOVER.
(Reproduced by kind permission from *Proc. Malac. Soc.*, Lond., vol. iii, p. 162.)



	ft. in.		ft. in.
1. Surface soil, with few angular flints	—		2 0
2. Dissolved-out flints, unworn	0 9	to	1 6
Helix aspersa extremely abundant.			
* Roman pottery.			
3. Chalk rubble	1 0	to	2 6

FIG. 34.
SECTION AT BUCKLAND, NEAR DOVER.
(Reproduced by kind permission from *Proc. Malac. Soc.*, Lond., vol. iii, p. 163.)



	ft. in.		ft. in.
1. Surface soil	1 0	to	1 6
2. Chalky marl, with angular flints	2 0	to	3 0
* Neolithic pottery. † Neolithic flints.			
3. Chalky marl, and brick-earth	4 0	to	5 0
* Small pocket of shells.			
4. Beds of Rubble Drift	—		—

We have not seen any examples, so nothing can be said as to the identifications, but if *Limnæa glabra* were correctly named, it is the only record of this local species from the Holocene, though it is known from the Pleistocene of Ilford and West Wittering.

18. Reigate.

The Holocene deposit at the Horse-shoe pit, Colley Hill, Reigate, and its contained Mollusca, formed the subject of a paper by the Rev. R. Ashington Bullen in 1898 (68). The species are thirty-five in number, and are set forth in our table. The presence of *Helix aspersa*, *H. pomatia*, and *Helicella cantiana* is noteworthy, these three species being extremely rare in deposits of any age, and *Buliminus montanus* has hitherto been only recorded from the Pleistocene of Cambridge and Clacton, and the Holocene of Blashenwell, whilst *Clausilia biplicata*, though often recorded, is only known from Blackfriars, Fulham, and the Pleistocene of Grays. Mr. Bullen is of opinion from the presence in abundance of the various slug-remains, as well as of *Carychium minimum* and *Helicigona arbustorum*, that far damper conditions prevailed during the deposition of the bed than now obtain in the locality.

19. Brighton.

Mr. J. P. Johnson has described a Holocene deposit near Brighton and has listed seven species of Mollusca as occurring in it (73). The bed is to the east of the town and consists of "3 feet of chalky rainwash overlying the palæolithic rubble-drift," and from the abundance in it of Neolithic flakes, it was considered to be of Neolithic age. The shells are:—

Helicella virgata,	*Helix aspersa*,
" *itala*,	" *nemoralis*,
" *caperata*,	*Pupa muscorum*,
" *cartusiana*,	

none of which call for any extended notice here.

20. Cissbury (Sussex).

If the various excavations which, from time to time, have been made on the site of the old flint workings at Cissbury, had been carefully watched for examples of Mollusca, and the various levels at which they occurred had been noted, there can be no doubt much valuable information would have been obtained. As it is, Cissbury is a magnificent example of lost opportunities. The late General Pitt-Rivers has described the excavations (32), and we gather from his paper that six species were found in undoubted Neolithic deposits:—

Vitrea cellaria,	*Helicigona arbustorum,*
Pyramidula rotundata,	*Helix nemoralis,*
Helicigona lapicida,	*Pomatias reflexus.*

Ie also notes that in the ditch were found "200 large snail s," probably *Helix aspersa,* "and the same number of *Helix ralis* and *Cyclostoma elegans*" (= *Pomatias reflexus*). We only been able to examine two series from Cissbury, one in ›ossession of Mr. D. Taylor, and another which was kindly to one of us by Mr. Miller Christy.

[here are eight species represented, viz.:—

Helicella itala,	*Helix nemoralis,*
Hygromia hispida,	,, *hortensis,*
Helicigona arbustorum,	*Pupa muscorum,*
Helix aspersa,	*Pomatias reflexus.*

Pupa muscorum is represented by two dwarfed examples, which submitted to Dr. O. Boettger for verification, since they red so much from the type.

All these examples are probably of Roman age.

21. St. Catherine's Down.

The hillwash at St. Catherine's Down, Isle of Wight, was first ced in 1836 by Mr. J. S. Bowerbank (2). Twenty years later, 856, Mr. H. W. Bristow recorded seven species as occurring e (13). This list was again given in 1862 by Mr. Bristow (20), was copied in 1888 by Mr. M. W. Norman (43). In 1889 srs. Reid and Strahan spoke of it as a chalk talus (45). They ribed it as being about 9 feet thick, and as "made up almost ely of small fragments of Chalk and chalk mud, but contains le Upper Greensand and a very few fragments of Chert. It early a rainwash from the slopes of a hill of Chalk which once have extended to the south, but of which the small er is the only surviving fragment. The remainder of the ıas slipped down to various positions in the undercliff, one of nost striking features of which is the great slices of Chalk and er Greensand still retaining their relative positions." They in a footnote that the record of *Helix aperta,* originally given Ir. Bristow (we believe on the authority of Prof. J. Morris), correct. Mr. A. Loydell has worked at this deposit for some s past, and he most generously placed his collection at our osal, while we are further indebted to him for the following mation. There are a number of sections exposing this bed ie neighbourhood of Ventnor and Bonchurch, but the compo- n is always the same and as described above. A fine section be seen in the quarry in the Undercliff, Ventnor, near Steep- View. There are good ones on the Steephill Estate, in the ing for the new road. As to the age of this deposit at the rry, a kitchen midden may be seen on the top of the

Paludestrina ventrosa (44), is a brackish water form. Mr. Kemp's examples came from five localities, and in his paper the species from each are listed separately. The localities are Netley Shoal, Southampton Dock, near Mattisfont in the Test Valley, the Itchen Valley, and the Anton Valley. The specimens from the last locality having been picked out of mole-hills on a malm knoll. These last are perhaps unsatisfactory specimens, as "top soil" shells are likely to have been mixed with the true tufa shells and it should be noted that one form, *Pomatias reflexus*, has only occurred at Anton. We are able to confirm the records of forty-six species, but six others recorded by Sir Charles Lyell we have not seen. They are listed on the authority of Dr. J. E. Gray.

24. Blashenwell.

The tufaceous deposit at Blashenwell, in the Isle of Purbeck, was first noticed in 1857 by Mr. J. C. Mansel (afterwards Mansel-Pleydell), who recorded fourteen species of Mollusca (16), but of this number five came from the surface soil. In 1885 the same author listed seventeen species, but in the second list no information is given as to whether the specimens came from the tufa or the top soil (41). In 1896 an extended notice was given by Mr. Clement Reid (62), who recorded twenty species, two more being added in an additional note. Mr. Reid had devoted some considerable time to the deposit, and was able to adduce many interesting facts in connection with the Mollusca. He pointed out that this deposit had ceased to be formed long before the Roman period, so that it is a true Neolithic deposit. This is of great importance, because so many of the Holocene beds are of doubtful age, whilst there is too often the possibility of an admixture at a later period.* The deposit is also of great interest, since it is one of the few English localities for that remarkable group of flint implements described by Mr. W. J. Lewis Abbott in 1895 (*Jour. Anthro. Inst.*, vol. xxv, pp. 122-145). Whether these implements should be considered early or late Neolithic is still a matter of dispute, but the existing evidence rather supports the former view. Mr Reid pointed out that at Blashenwell there was no possibility of confounding *Helix nemoralis* with *H. hortensis*, the two forms being quite distinct. The former is always larger and without bands, whilst the latter is smaller and invariably banded. This is very remarkable, because in the living state the banded form of *H. nemoralis* is always greatly in excess of unicoloured individuals, and the same holds good in examples from other deposits. He also noted that examples of *Helix aspersa*, *Helicella virgata*, and *H. itala* were found in the layer of black earth of Roman age overlying the deposit, though

* In some soils bits of pottery and coins have been found to work down into lower layers. See *Ann. Rept. Plymouth Instit.*, vol. xii (1896), p. 109 and p. 119.

they were absent from the tufa, thus clearly showing they were of more modern introduction. It should, however, be pointed out that the deposit probably accumulated whilst the surrounding country was well wooded. The three forms above mentioned are more characteristic of open country than of woodland areas, so that it is simply a question of environment, these forms migrating into the district when the conditions were suitable. We have no fresh records to announce, but it has been considered advisable to reject five of the species recorded by Mr. Mansel-Pleydell—*Helicella virgata*, *H. itala*, *H. cantiana*, *Succinea oblonga*, and *Limnæa pereger*. We have listed four species on his authority, three of which are aquatic forms.

25. Dewlish, Dorset.

By Dr. H. P. Blackmore.

At Dewlish, in Dorset, the boldly curved Chalk escarpment runs N.E. of the valley through which courses, in rainy seasons, a small tributary of the River Puddle—the channel in the summer time is now frequently quite dry. In September, 1898, whilst examining the Pliocene deposit described by Mr. Clement Reid,* a number of trenches were cut at various levels on the hillside. The fourth trench (opened about a third of the way up, from the base of the hill) showed the wash of the hill and chalky rubble, which, in the other trenches remarkably thin, was here nearly 4 feet thick; immediately below this was a bed of clean, fine, white siliceous sand, from 2½ to 3 feet thick, very similar to that mixed with the loose flint gravel of the Elephant Bed on the top of the hill.

Irregularly scattered throughout this fine sand were a number of land shells, very perfect in form, and, in many instances, still showing traces of the original colour.

Even in the short time at one's disposal, and in the limited space excavated, the following species were found :—

† *Vitrea cellaria*,	*Helix aspersa*, 9,
Helicella virgata, 3,	† „ *nemoralis*,
„ *itala*, 2,	„ *hortensis*, 6,
Hygromia hispida, 2,	*Clausilia laminata*, 1,
„ *rufescens*, 1,	*Pomatias reflexus*, 48,
Helicigona lapicida, 2,	

All these species are found living in the immediate vicinity; they are inhabitants of dry downs, and might easily have been entombed by wind-blown sand; this is especially noticeable in the case of the shells of *Helix aspersa*, which with the single

* *Memoirs of the Geol. Survey*—"Pliocene Deposits of Britain," 1890, p. 206-8.
† These two shells were found and identified Mr. J. C. Mansel-Pleydell.

exception of one small fragment, are all those of young snails, not more than half-grown in size, and hence very light and easily transported.

This fine sandy deposit showed no sign of stratification, and was evidently not deposited by water, but is a patch of wind-blown sand filling up an irregular hollow in the hillside; a point also proved by the irregular manner in which the shells were scattered throughout the mass.

Below this patch of fine white sand was a fairly regular band of small loose gravel, stained yellow. This gravel was clearly water-worn, made up of small sub-angular fragments of flint, with neither Tertiary pebbles, nor large-sized flints. In this gravel were found a few fragments of water-worn bones, too small for identification, but from their size and thickness such as might have belonged to deer or ox, certainly not large enough for elephant; also the distal half of a metatarsal bone of a young animal, probably a very small ox or deer, too imperfect for more exact identification. But with this last was a small fragment, the distal end of a left radius of a small sheep, similar to the remains found at the Highfield Pit dwellings and other deposits of Neolithic age.

This fact taken in conjunction with the shell fauna, shows that the deposit of wind-blown sand is of Holocene age, and that it assumed its present position long after the accumulation of the upper deposit of gravel and sand in which the remains of *Elephas meridionalis* occur.

26. Castle Cary, Somersetshire.

There is in the collection of one of us a small series of shells from an alluvial deposit at the above locality, of which we have been unable to obtain any information. The species, eight in number and obviously of no great antiquity, are :—

Hygromia hispida,	*Ancylus fluviatilis,*
,, *rufescens,*	*Bithynia tentaculata,*
Helix hortensis,	*Valvata piscinalis,*
Cochlicopa lubrica,	*Pisidium amnicum.*

27. Bath.

In 1870, Mr. C. Moore recorded seventeen species of shells as having been found in the prehistoric alluvium (*i.e.* pre-Roman) at Bath, and at the same time he listed eleven species as having been found within Roman coffins (29). We have not seen these specimens, and are thus unable to say whether the identifications are correct. The pre-Roman species recorded are :—

Pyramidula rotundata,
Helicella barbara,
Hygromia hispida,
Vallonia pulchella,
Helix hortensis,
Cochlicopa lubrica,
Azeca tridens,
Clausilia nigricans[= *bidentata*],
Limnæa pereger,
" *stagnalis*,
Planorbis albus,
" *nautileus*,
" *spirorbis*,
Pomatias reflexus,
Sphærium corneum.

All these forms are known from both the Pleistocene and Holocene beds. The species of Roman age are:

Limax sp.,
Vitrea crystallina,
" *nitidula*,
Pyramidula rotundata,
Hygromia hispida,
Vallonia pulchella,
Cochlicopa lubrica,
Cæcilianella acicula,
Pupa muscorum,
Clausilia bidentata,
Carychium minimum.

In the British Museum (Natural History) is preserved a series of six species from the Roman bath, presented by R. E. Etheridge and R. Bullen Newton, and undoubtedly of Roman age. The species are:—

Pupa umbilicata,
Clausilia bidentata,
Limnæa pereger,
Planorbis marginatus,
Paludestrina ventrosa,
Bithynia tentaculata.

The only noteworthy species are *Pupa umbilicata*, a form which is extremely rare in the deposits of this country, and *Paludestrina ventrosa*, an inland locality being a very unusual habitat for this brackish water form.

28. Widemouth Bay (Cornwall).

Mr. W. A. E. Ussher has kindly sent us a small series of shells from Widemouth Bay, south of Bude, Cornwall, that were obtained at a depth of from one to two feet from the surface with Neolithic flakes. The species represented are three in number, viz.:—

Helicella virgata,
" *caperata*,
" *barbara*.

It is impossible to say anything about the age of these shells, but they are probably of later age than the flint flakes.

29. The Cornish Towans.

The Mollusca which have been found, often at great depths, in the sand hills or "towans" of Cornwall, have been catalogued on several occasions (see Bibliography 4a, 5), but it is quite impossible to say anything definite about their age, except that in many cases they are very probably quite modern. Mr. A. Bell kindly sent us a small series from near Lelant church, in which eight species are represented:—

Vitrea nitidula,	*Helicella caperata*,
Pyramidula rotundata,	„ *barbara*,
Helicella virgata,	*Helix aspersa*,
„ *itala*,	„ *nemoralis*.

These examples are certainly of no great age, judging by their condition. Many of the species recorded are certainly incorrect, and it is better to ignore all the previous lists.

D.—PLEISTOCENE DEPOSITS.

1. Chilton, Berkshire.

The bed of angular drift and its contained fossils, between Upton and Chilton, was first described in 1882 by Professor J. Prestwich (38), who again listed the Mollusca in 1892 (50). The deposit is of great interest, lying as it does between 300 and 400 feet O.D., and containing no northern material. That it is of Pleistocene age is proved by the presence of the characteristic Mammalia. The Mollusca were determined by Dr. Gwyn Jeffreys, and, though we have been unable to trace the specimens, there is no reason to question the records. The species are:—

Agriolimax agrestis,	*Succinea oblonga*,
Hygromia hispida,	*Limnæa truncatula*,
Pupa muscorum,	*Planorbis albus*.

All the forms are well-known Pleistocene species, and call for no comment.

2. Green Street Green, Farnborough.

The fine sections in the Pleistocene gravel at Green Street Green, from which the remains of *Elephas primigenius* (Blum.), *Equus caballus* (Linn.), and *Ovibos maschotus* (Zimm.) have been obtained, are well known. From the nature of the deposit it could hardly be expected that molluscan remains would occur, but Prestwich records finding "in the smaller pit a few examples of *Pupa muscorum* in a thin intercalated seam of loam" (50). One of us has made repeated visits to the pits, and a large quantity of the loam has been washed, with negative results; but, though no examples are known, there is no reason to doubt this record.

3. The Ightham Fissures.

From a palæontological standpoint, by far the most important Pleistocene beds in the South of England are the fissure deposits at Ightham. They were originally worked by Mr. W. J. Lewis ɔott, who described the fissure and its invertebrate remains in 4 (54). Up to that time seventeen species of Mollusca had arded Mr. Abbott's labours, and this list was again given later in the same year (55). Mr. Abbott continued to work at the osit, and in 1897 we were able to record twenty-nine species). Of course, the most important question is, "What is the of this deposit?" We think there can be but e doubt that it is Pleistocene, though there has n a slight accidental admixture in quite recent es. The bulk of the work done in the autumn winter of 1889 was confined to the uppermost : of the fissure, and it was found that the locally nct voles occurred throughout. There is no poslity of dividing it into zones, the whole of it is :tically of one age. We cannot correlate it with other Pleistocene bed, as the Mollusca are all l forms, and the smaller vertebrate remains are 'ce in deposits of this age elsewhere. Several :nples of *Helix aspersa* have been found, but r condition and mode of occurrence proves clusively that they have been recently introed into the fissure.

FIG. 35. *Carychima minimum*, Müll., Var., much enlarged.

'wo examples of *Carychium minimum* differ so much from the : as to merit extended notice. They are much more slender orm, not exceeding ·75 mm. in width, but being quite 2 mm. ıeight. The whorls are six in number, more closely coiled, consequently longer and increase more gradually all through, hat the spire is higher and more tapering. The body-whorl ıuch less in proportion. The mouth is more rounded and not stricted at the outer tooth; on the other hand, the tooth :lf is greatly reduced and is represented by a mere thickening the labrum. The columella teeth are not more than onerd the size of those in recent examples, and occur far back ide the whorl so as to be invisible when the shell is viewed iquely. The peristome is more reflected and less thickened.

4. Crayford and Erith.

A full account of the Mollusca from these deposits was given t 890 (49). Since then one of us has worked very extensively - new section, and *Agriolimax agrestis* was recorded in 1895) and *Littorina rudis*. Mr. A. Loydell placed a small series shells from the Erith pit at our disposal, and amongst them a single example of *Acicula lineata* (which has since ununately been destroyed). We have only two other new ɔrds, *Cæcilianella acicula*, an apical fragment of which was ained at a depth of fourteen feet from the surface, and *'idium nitidum*. Some examples of *Pisidium* differed so much m any living English forms that we submitted them to Dr.

O. Boettger. He is of opinion that they are *Pisidium amnicum*, var. *danubialis*, now living in the neighbourhood of Vienna, and an examination of a recent example he sent us enables us to agree with the identification. In its outline it resembles *P. fontinale*, but is of course much larger. We have not seen living examples of it from this country. It is noteworthy that two species, *Helicigona arbustorum* and *Clausilia bidentata*, are only known from the railway cutting, and have not yet been found in the various brick pits.

The complete list of the Mollusca is given in the table.

5. Dartford.

Examples of Mollusca from the high terrace gravel of the Thames in Kent were found by Mr. F. C. J. Spurrell, at Dartford Brent, west of the Asylum, and were recorded by Mr. E. T. Newton in 1896 (61). The species were four in number, viz.:—

Bithynia tentaculata, *Corbicula fluminalis*,
Valvata piscinalis, *Pisidium fontinale*.

Unfortunately the specimens have since been lost; but there is no reason to doubt the identifications.

6. Swanscombe.

In the early part of last year, Mr. H. Stopes kindly informed us that a new pit had been opened in the high terrace gravel of the Thames at Swanscombe, and was yielding abundant molluscan remains. It was described by Mr. H. Stopes shortly after, and a list of twenty-three species given on the authority of one of us (74). Since then repeated visits have been made to the section, and large collections made, so that we are now able to tabulate forty-two species, several of which are of great interest. The pit is situate on the west side of Ingress Vale, and shows about 14 feet of sandy gravel resting on the Chalk, which is here 78 feet O.D. The bed undoubtedly belongs to the high terrace, and is of the same age as the gravel at Milton Street and Galley Hill, both of which have yielded an abundance of flint implements, whilst the latter pit also yielded the human skeleton obtained by Mr. R. Elliott (61). Considerable doubt has been expressed in some quarters as to the Palæolithic age of these remains, and this discovery furnishes additional proof of their great antiquity. The shells are extremely abundant, and most of the examples of *Neritina* still retain their coloration. Many are encrusted with carbonate of lime, a condition which is also observable in the shells from the Thames and Lea alluvium. Numerous vertebrate remains have been found, as well as flint implements. Many of the Unios are in the position of life with the valves united, and the ligament is often preserved. The most abundant molluscan species are *Neritina fluviatilis*, *Bithynia tentaculata*, *Valvata piscinalis* and *Corbicula fluminalis*.

Valvata piscinalis is, as is usual, polymorphic, and varied from he high-spired var. *antiqua* to the flattened var. *depressa*. Some xamples of this species differed so much from any recent British xamples that we submitted them to Dr. O. Boettger for verification. He informs us that it is the *Valvata naticina* Menke, a orm which is still living in N.E. Germany, and which is known rom the lower Pleistocene of Mosbach, near Wiesbaden, and the Middle Pleistocene of Mauer, near Heidelberg, but that in his pinion it cannot be considered a distinct species, being only a ariety of *V. piscinalis*. The importance of this deposit is very reat, as it practically furnishes all the evidence we have as to the auna of the high terrace. It has been suggested by some observers hat these gravels are marine, whilst by others they have been onsidered to have been deposited under much colder conditions han now occur. Both these views are now shown to be incorrect, he fauna indicating a climate very similar to our own. It is oteworthy that this deposit shows no trace of marine conditions, nd thus that the mouth of the Thames must have been at that ime far away in what is now the North Sea. The presence of *Veritina fluviatilis* and the general facies of the shells indicate a uick-flowing stream.

The occurrence of *Vivipara clactonensis*, S. V. Wood, is ommented on later. No less than six species, now extinct in his country, have been found at Swanscombe, a record for the Pleistocene, which is only equalled by Barnwell. With the human emains at Galley Hill, Mr. R. Elliott found examples of *Caecilianella acicula*, which is also known from Swanscombe. The workmen at Milton Street pit informed us that some years go a large number of shells were found in a sandy layer, but one were preserved.

7. Maidstone.

In 1836, Prof. J. Morris noted (3) three species of Mollusca as aving been found in a section half-a-mile from the bridge on the ondon road and at a height of from 80 to 100 feet above the river, nd this is probably the origin of the footnote in Sir Roderick Iurchison's paper (8), where the same three species are recorded. n 1865, Messrs. C. Le Neve Foster and W. Topley mentioned x species as having been found in the Iguanadon Quarry (24), nd this list was again given by Mr. W. Topley in 1875 (34). 'hough we have been unable to trace the specimens on which ese records were founded, yet specimens are extant from everal localities in the neighbourhood of Maidstone in part conrming the previous records as well as adding several new species.

Buried in the Geological Society's Museum are examples of *uccinea oblonga* from "under the Warp in the Valley of Medway, few miles above Rochester." In the same collection are five ecies from "Railway cutting near Rochester." The species are :

Hygromia hispida, *Succinea oblonga*,
Helix nemoralis, *Pomatias reflexus*,
Pupa muscorum,

These examples are probably from the same section as those specimens in the Prestwich Collection at the Natural History Museum labelled, "In brickearth over gravel in the railway cutting Maidstone, Strood Branch."

There are ten species in this latter collection, viz. :—

Vitrea cellaria, *Carychium minimum*,
Pyramidula rotundata, *Limnæa truncatula*,
Hygromia hispida, *Pomatias reflexus*,
Helix nemoralis, *Acicula lineata*,
Clausilia laminata, *Pisidium pusillum*,

There are also two species in the Prestwich Collection from "Loess, Buckland, near Maidstone," viz. :—

Pupa muscorum, *Succinea oblonga*.

The latter is also represented in the Natural History Museum, by examples from Maidstone, presented by Mr. W. H. Benstead, and probably ftom the Iguanadon Quarry. Since these shells are all probably of the same age we should have listed them together; twelve species in all being represented, whilst two, *Vitrea fulva*, and *Cochlicopa lubrica* are added on the authority of Mr. Etheridge, who was responsible in the first instance for their identification.

8. Upchurch.

Sir Joseph Prestwich has recorded (50) Mollusca as occurring in a lenticular layer of grey laminated clay in gravel under the brick earth. The species he names are :—

Pupa muscorum, *Succinea oblonga*.

We have been unable to trace these examples, but there is no reason to doubt the identifications.

9. Swalecliffe.

This deposit is situated about a mile west of Herne Bay, and was first noticed in 1861 by the late Sir Joseph Prestwich (19). He pointed out that "the deposit, although consisting of tenacious clay with an interstratified bed of sand and gravel, is more related to the löess in its organic remains than to the Wear Farm deposit, for hitherto, although the *Pupa marginata* and *Succinea oblonga* are extremely abundant, and a small *Helix* is not rare, yet I have not been able to obtain a single truly aquatic shell." The only other extended notice of the bed was by Sir John Evans, last year (Ancient Stone Implements of Great Britain, 2nd Ed., p. 617) who stated: "At Swalecliffe, near Whitstable, there are more argillaceous freshwater beds at a lower level containing land and marsh shells, but these seem to be comparatively modern and connected with the small lateral valley, rather than with the main valley of the Thames, or of any other ancient river." A recent visit, however, paid by one of us to this deposit does not support this view. Judged by the sections now visible, this deposit is underlain by the same gravel as the brickearth containing the remains of *Elephas* and *Hippopotamus*. A similar deposit is to be seen at the base of Studhill cliff, on the top of which were the scanty remains of a marine deposit containing *Mytilus edulis*. In all probability the higher gravels are of the same age as the upper terrace of the Thames, at Galley Hill and elsewhere, whilst these lower beds are the equivalents of the middle terrace of Crayford, Ilford, and Grays. The Mollusca, though extremely abundant in numbers, are few in species. There are a few examples in the Prestwich collection whilst a fair series is in our possession, and from these we are able to list six species :—

Agriolimax lævis,	*Pupa muscorum,*
Arion ater,	*Succinea oblonga,*
Hygromia hispida,	*Limnæa truncatula,*

Of these *Hygromia hispida* is extremely rare, *Succinea oblonga* and *Pupa muscorum* being the most abundant; *Arion ater* has hitherto been only recorded from Ilford, though occurring in deposits of that age in the valley of the Somme, in France; *Agriolimax lævis* has been found at Cambridge and at the Admiralty section, Westminster.

10. Wear Farm, Chislet.

This deposit was first described and the contained fossils listed in 1855 by the late Sir Joseph Prestwich (12), the shells having been identified by Mr. Pickering. In 1858 Mr. John Brown, of Stanway, described another section (17) situate on the left hand side of a lane leading from the railway station (Grove Ferry) to the little village of Upstreet, nearly a mile from the village of Chislet. A list of fossils, principally marine, is given on the authority of Mr. G. B. Sowerby, several forms being described and figured as new. The non-marine shells are: *Cyrena consobrina* [= *Corbicula fluminalis*], *Helix* sp., *Valvata piscinalis* and *Limax* sp. The last named is figured, *Quart. Journ. Geol. Soc.*, Vol. 15, Plate 5, Fig. 3, a—c, and is in all probability *Agriolimax agrestis*, although it is stated to differ from that form, but, the specimens having been lost, it is impossible to settle the point. Of existing examples we have been able to trace two series, both in the Natural History Museum, one of which is part of the Prestwich collection, and four species are there represented, viz. :—

Ancylus fluviatilis,	*Bithynia tentaculata,*
Paludestrina ventrosa,	*Corbicula fluminalis.*

All these forms are from Wear Farm, and have been recorded from there. We have been unable to trace any specimens from Upstreet, and so are unable to add anything to our scanty knowledge of that deposit.

11. Buckland, near Dover.

The Holocene series at this locality we have already dealt with (ante p. 236). The Mollusca from the underlying Pleistocene, also treated of in 1898 by the Rev. R. Ashington Bullen (66), number seven species. In the Prestwich collection at the Natural History Museum are a few examples labelled, "Loess, Buckland, near Dover," and three species are represented, but of these two were also found by Mr. Bullen. The eight species are:—

Agriolimax agrestis,	*Cochlicopa lubrica*,
Hygromia hispida,	*Pupa secale*,
Vallonia pulchella,	,, *muscorum*,
Helicigona arbustorum.	*Succinea oblonga*.

The most interesting form is undoubtedly *Pupa secale*. This species not having been recorded from any deposit in this country, though, as already noted (ante p. 230), it occurs in the Neolithic hill wash at St. Catherine's Down. The remaining species are common Pleistocene forms, and call for no further notice.

12. Folkestone.

Mr. S. J. Mackie, in 1851, was the first to describe the Pleistocene beds in the neighbourhood of Folkestone (7), and he named four species of Mollusca as occurring there: two from the brickearth on the top of Westcliff, and three from Gambrill's pit. These records were copied in 1864 in the Geological Society's Memoir (22), and were again given in 1865 by Mr. Mackie (25). In 1892, Prestwich mentioned eight species, all determined by Gwyn Jeffreys, as having been found with mammalian remains in a bed of chalk rubble on the top of the cliff of the Lower Greensand, under the Battery at a height of eighty feet above the sea (50). We have only been able to see three species, now in the Prestwich collection at the Natural History Museum. They are:—

Hygromia hispida,	*Succinea oblonga*,
Pupa muscorum,	

The following records rest on the authority of Dr. J. Gwyn Jeffreys:—

Hygromia rufescens,	*Succinea putris*,
Vallonia pulchella,	*Bithynia tentaculata*,
Helix nemoralis,	*Pomatias reflexus*.

13. Portfield, near Chichester.

The only mention of this deposit is that made in 1892, by Prestwich (50), who noted that at Portfield, near Chichester, the rubble gravel is intercalated with thin lenticular seams of sand and loam, in which the late Mr. Hill, curator of the Chichester Museum, found:—

Helix nemoralis,	*Pupa marginata*,
,, *concinna*,	*Succinea putris*,
,, *pulchella*,	*Zua lubrica*.

In the Prestwich collection at the Natural History Museum six species of shells, labelled, "Portfield, near Chichester," on ich, presumably, the above list was founded. The species, vever, represented are :—

Hygromia hispida,	*Pupa muscorum,*
Helicigona arbustorum,	*Succinea elegans,*
Cochlicopa lubrica,	*Planorbis spirorbis.*

The species are all common Pleistocene forms, and call for no :her remark.

14. Selsey.

Situate on the borders of Sussex and Hampshire are three ;iliferous Pleistocene deposits, which, though not of great ≥nt, are yet of extreme interest from their contained fauna and a, because it is from them that the strongest evidence in favour . warm interglacial period has as yet been adduced. Two of se beds, viz., Selsey and West Wittering are in Sussex, and the d, at Stone Point, is in Hampshire. The first notice of the deposit Selsey was in 1850, when Mr. F. Dixon recorded three species of -marine Mollusca on the authority of Mr. G. B. Sowerby (6). : species were : *Helix nemoralis, H. hortensis,* and *Assiminea* *'ana,* the last species being given with a query. The next of any importance was in 1878, when Mr. A Bell listed six :ies (36), and in 1893 the same author recorded fifteen species , one of which, *Hydrobia compactilis,* was described and 'ed as new to science. The only existing specimens we have able to trace are those in the York Museum, and a few nples of *Paludestrina stagnalis* in the Museum of Practical logy. Seven species are represented, three being new, viz. ; *orbis glaber, P. nautileus,* and *Pisidium pusillum.* The type *ydrobia compactilis* is at York, and after a careful examination annot differentiate it from the polymorphic species, *Paludes-* *z stagnalis,* an opinion in which we have the concurrence of E. A. Smith. *Hydrobia subumbilicata* is only a variety of *'destrina ventrosa.* The two other species which we have are, *Planorbis spirorbis* and *Leuconia bidentata.* Of the ining ten recorded species seven are known from West ering, viz. ;—

Hygromia hispida,	*Planorbis marginatus,*
Helix nemoralis,	*Bithynia tentaculata,*
Limnæa pereger,	*Pisidium amnicum.*
" *palustris,*	

Assiminea grayana "is" without doubt an error, and *Helix* *tensis* rests on the authority of Mr. Sowerby, and *Planorbis* *'tex* on that of Mr. A. Bell.

15. West Wittering.

The first notice of this deposit was in 1878, by Professor T. Rupert Jones (36), when he noted "Teeth and bones of Rhinoceros, together with several species of land and freshwater shells, have lately been discovered by Mr. H. Willett, F.G.S., near East Wittering, in a deposit beneath the glacial beds of Selsey." In 1892, Mr. Clement Reid described the deposit and recorded thirty-six species of non-marine Mollusca. During the past two years Mr. J. P. Johnson has carefully worked the beds, and we are greatly indebted to him for a record of the species he has found. The examples on which Mr. Reid's list was founded are now in the Museum of Practical Geology, and after an examination of the specimens, the following alterations are necessary. *Helix rupestris* should be *Punctum pygmæum*, and *Clausilia biplicata* should be *C. bidentata*. No less than fifty-eight species are now known from this locality, being a larger number than from any other deposit in the south of England.

Limnæa glabra is a very noteworthy form, since it has hitherto only been found at Ilford, and there is only represented by a single example. The occurrence of *Acanthinula lamellata* greatly extends the range of this species in Pleistocene times. It has hitherto been undetected south of the Thames, either living or fossil. Amongst the examples of *Limnæa palustris* is one of the short dumpy variety (figured in *Science Gossip*, New Series, Vol. II, p. 39), found also at Crayford, Harwich, and Ilford. One example of *Sphyradium edentulum* is the form known as var. *columella*, Mts., which on the continent, is considered a distinct species.

16. Stone.

The deposit at Stone was discovered by Mr. Clement Reid, and described by him in 1893 (53). It is situate on the foreshore at Stone Point, three miles south of the village of Fawley and the same distance from the entrance to Southampton Water. Mr. Reid informs us that it is almost impossible to collect there, as the bed is only exposed at low water, and the foreshore being almost level, any excavation is at once filled with water. Four species of non-marine Mollusca were found and the examples are now at the Museum of Practical Geology, Jermyn Street. They are:—

Vallonia pulchella,	*Paludestrina ventrosa*,
Paludestrina confusa,	,, *stagnalis*.

It was here also that Mr. Reid obtained the seeds of the south European maple *Acer monspessulanum* (Linn.).

17. Freshwater.

In 1862 Mr. H. W. Bristow noted that at Freshwater, Isle of Wight, in a deposit of brickearth, *Pupa muscorum* and *Succinea oblonga* had been found (20). We have seen no examples from this locality, and hence we are not in a position to say whether the identification was correct.

18. Fisherton and Milford Hill, near Salisbury.

This well-known Pleistocene deposit was first described in 1855 by J. Brown and Joseph Prestwich (11). Twenty-one species of Mollusca were recorded, and remarks made as to the relative frequency of their occurrence. In the following year, twenty species were listed by Mr. S. V. Wood (14), on the authority of Mr. J. Brown, whilst in 1864 Sir John Evans noted thirty-one (23), Dr. Blackmore this time being responsible, though he informs us that Gwyn Jeffreys checked the identification. In 1867 Dr. Blackmore (25a) republished the list with minor alterations that reduce it to twenty-nine species. Of existing specimens there is a fine series preserved at the Natural History Museum containing twenty-one species; whilst Dr. Blackmore's specimens are in the museum at Salisbury, and we greatly regret that we have been unable to examine these specimens. Three species in Dr. Blackmore's list being now considered only varieties of other forms, there are only ten records to be accounted for.

Of these we have rejected three, viz., *Helix sericea* [= *Hygromia granulata*], *Vertigo* [= *Sphyradium*] *edentula*, and *Limnæa auricularia*, all of which, though recorded by Wood, are not in Dr. Blackmore's list. The remaining species are represented,)r. Blackmore assures us, in the Salisbury Museum, and hence e have listed them as occurring at Fisherton.

These species are:—

Pyramidula rotundata,
Helix nemoralis,
Succinea elegans,
Planorbis carinatus,
Planorbis spirorbis,
Bithynia tentaculata,
Acicula lineata.

We have only one new record, *Cæcilianella acicula*, a form ich is rather rare in the Pleistocene, though often given in error, ent examples being mistaken for true fossils.

Dr. Blackmore (25a) also describes a section in the Drift in L. & S.W. Railway cutting at Milford Hill, where "near base of the gravel a narrow seam of loose, light-coloured sand, ntaining shells, was discovered. The shells in this one spot isted in the greatest abundance. . . . They consisted prin-ally of *Helix hispida* in all stages of its growth, a few specimens *Helix arbustorum*, and a single individual of *Zua subcylindracea*. . . With the single exception of a fragment of an upper olar tooth of a species of *Equus*, no bones or mammalian emains have as yet been discovered."*

* We are not certain whether the lower valley gravel of the Avon at Bickton Mill, Fordingbridge, belongs to this same series or not, *Pupa muscorum* being the sole species of mollusc as yet obtained therefrom.

19. Portland.

The first person to place on record the occurrence of non-marine Mollusca in the rubble drift at Portland Bill was our esteemed President, Mr. W. Whitaker, who, in 1869, mentioned that *Bithynia* and *Pupa* had been found there (28). In 1875 Prestwich alludes to eight species, all of which had been determined by Dr. J. Gwyn Jeffreys, from Portland Bill and Chesilton Cliff (33). This list was again given in 1892 by the same author (50), with the exception that *Helix* [= *Helicella*] *virgata* is included, and *Planorbis albus* does not occur. The following year Mr. A. Bell recorded *Helix nemoralis* (52), whilst in 1894, the Rev. R. Ashington Bullen published the names of species on the authority of Mr. E. A. Smith, which he himself had found at the Bill (56). In 1895 Mr. E. R. Sykes noted that he had found two examples of *Limnæa truncatula* in the raised beach, the other non-marine forms having been obtained from the rubble drift over the beach. He also tabulated the records from Portland Bill and Chesilton (58). Last year the Rev. R. Ashington Bullen again noted three additional species (72). Of existing examples we have only seen the specimens found by the last-named observer and Mr. E. R. Sykes. The known forms are :—

Helicella itala,	*Succinea oblonga,*
Hygromia hispida,	*Limnæa pereger,*
,, *rufescens,*	,, *truncatula,*
Vallonia pulchella,	*Pomatias reflexus.*
Pupa muscorum,	

The following rest on the authority of Dr. J. Gwyn Jeffreys:—

Agriolimax agrestis,	*Planorbis glaber*
Helicella virgata,	*Bithynia tentaculata,*
Planorbis albus,	

whilst Mr. A. Bell is responsible for the record of *Helix nemoralis.*

Portland Fissures.

From fissures in the Isle of Portland examples of *Vitrea cellaria* have been obtained, and examples of this species are now preserved at the Natural History Museum. In all probability these shells are of Pleistocene age, but of this no direct evidence is forthcoming.

20. Happaway Cavern.

The only known Pleistocene non-marine Mollusca from the county of Devon are a series of seven species from the Happaway Cavern near Torquay and now preserved in the Natural History Museum. They were collected by the late Mr. W. Pengelly (whose widow presented them to the National collection) and they received from him the usual treatment meted out to the poor

ortunate Mollusca by all cave explorers. He dismissed them
ı the remark that "shells of terrestrial mollusca were more
nerous and varied, but those of *Helix* were the most prevalent"
ans. Devon Assoc., 1886, vol. xviii, p. 165). They were
cribed by us in 1897 (64). The species are :—

Vitrea alliaria,	*Helix nemoralis,*
,, *cellaria,*	,, *hortensis,*
Pyramidula rotundata,	*Pomatias reflexus.*
Helicella caperata,	

It is noteworthy that all these forms are also found in the
tham fissure. Some of the examples of *Pomatias reflexus* still
in their opercula, whilst several specimens of *Pyramidula*
ndata were the high spired variation named by Dr. J. Gwyn
reys var. *pyramidalis*. Two examples of *Vitrea lucida* were
in the collection, but they are obviously from the top soil.

21. Newquay.

Just at the neck, where the Towan Head promontory joins the
nland and near the lifeboat house, a small quarry in the cliffs
the east side offers an interesting little section.

The upper layer consists of a rubbly sand, resting on the
urned edges of the Devonian rocks, and about thirty or more
: above highwater mark.

This sand, about 4 ft. thick, is throughout full of land
lls, with some marine ones, notably layers of *Mytilus*, which
ur about 2 ft. 6 in. from the base.

It is probably a portion of the "raised beach," indicated on
Survey map as occurring on both sides of the headland.
:ed southwards it manifestly passes up into, and forms part of,
urface soil on the high ground, which is surmounted by the
ntic Hotel. The deposit is consequently a hill-wash that has
mulated at sea level and received accessions from the sea.
ne same time it is of far too friable a nature to have been
sed to the beat of the waves, and one is driven to the
lusion that the accumulations of blown sand, which flank the
sit on the west, and form the coast in Fistral Bay, must, at
ime of its deposition, have existed on the east side also, and
: sheltering the deposit from the action of the waves, have
itted the formation of a salt water lagoon in which the
els lived, and into which the washings of the hill above found
way.

The land shells present include :—

Helicella virgata,	*Helicella caperata,*
,, *itala,*	,, *barbara.*

se are all in good preservation and frequently retain traces of
coloration.

t is curious that the land shells so far found in this particular section all belong to the one genus *Helicella*. One example of *Helix nemoralis* was seen higher up the hill in a small road cutting, but apparently, though well below the surface soil, it belonged to a later period than that represented in the section in question.

Amongst the marine species, which were mostly fragmentary, are :—*Littorina obtusata*, *Rissoa*, *Patella*, *Mytilus*, *Pecten*.

22. Barnstaple.

In 1892 (50) the late Sir Joseph Prestwich mentioned that under blown sand at Barnstaple three species of land shells had been found which had been identified by Dr. J. Gwyn Jeffreys as
Helix [= *Helicella*] *virgata*, Da Cost.
„ „ *cantiana*, Mont.
Bulimus ventricosus, Drap.
[= *Helicella ventricosus*, Drap.]
and he pointed out that the latter is a South European species, its most northern habitat being the south-west coast of France. Unfortunately we have been unable to trace these specimens; more especially is this to be regretted because the last-named species is of great importance. If this record is correct, it is the only known instance of the species having been found in this country, either recent or fossil. Dr. W. H. Dall, in answer to our enquiry, kindly informed us that there are no specimens of this shell from England in the Gwyn Jeffreys collection now at Washington, so it may be an error in identification for *Helicella barbara*. This locality is ignored in our table.

E. AGE OF THE DEPOSITS.

It is impossible to speak with certainty as to the relative ages of the various deposits. Very much more careful field work will have to be done before we shall be able to ascertain the true age of the numerous beds classed as Pleistocene. With regard to the Holocene deposits, however, we have more definite information. Blashenwell is certainly Neolithic, so, too, is the rainwash at St. Catherine's Down. Crossness, Blackfriars and Greenhithe, are probably Bronze age, whilst Newbury may belong to the same period. The ages of the Charing, Exedown, Reigate (older portion), and Hampshire tufaceous beds are uncertain, though they are all pre-Roman. Buckland is pre-Roman, whilst Darenth and Otford are post-Roman.

F. NOTES ON THE SPECIES.

We have listed one hundred and thirty-eight species of non-marine Mollusca as existing in this country,* and ten extinct

* Mr. E. A. Smith has lately described a new form of *Paludestrina* as *P. taylori* from Dukinfield, Cheshire (*Ann. Mag. of Nat. Hist.* (1901), Ser. 7, vol. vii, pp. 191-2), but though quite distinct it may prove to be an introduction from abroad.

orms. There are several other species which have been considered British, but in our opinion they have no true claim to that position. *Planorbis dilatatus* Say, is an American species existing in two or three localities in Lancashire, whilst *Physa heterostropha* Say, is found in a pond near Birmingham and also in Lancashire. Large numbers of the latter species have been sent to this country alive during the last few years, and it is obviously an introduction. Such species as *Opeas goodalli* Mill., *Clausilia cærulea* Drap., *Pupa cinerea* Drap., and *Helicella elegans* (Gmel.), cannot be considered in any true sense British. It is the custom in some quarters to call the last-named species *Helix terrestris* Penn., but it is not the same as Pennant's species. In 1897, Mr. J. W. Taylor figured and described "a probably new species of *Azeca*" from two examples, one from North Wales and the second from Ingleton, Yorkshire, under the name of *Azeca elongata*.* They are obviously monstrosities of *Azeca tridens* (Pult.).

Limax maximus is now known to occur in both Holocene and Pleistocene deposits, and should be considered indigenous to this country. Slug-remains are naturally scarce in all deposits, but besides *Limax maximus* we can now record *Arion ater* and *Agriolimax agrestis* from beds of both ages, whilst *A. lævis* is known from the Pleistocene, and *Arion hortensis* from the Holocene. *Vitrea lucida* is as yet unknown in a fossil state, though it occurred as a "top-soiler" in the Happaway Cave. On the Continent, according to A. Locard,† it is known from the Middle Pleistocene of France and Switzerland. Its distribution in these islands is such as to militate against the theory of its being a modern introduction.

With the exception of *Vitrea lucida* and *V. excavata*, all the English species of the genus are here recorded fossil, and the latter form is known from the Pleistocene of Copford and Clacton. *V. alliaria* is only known from Ightham and the Happaway Cave. *Pyramidula rupestris* is one of the very few species which have not yet been detected in any deposit, though it is undoubtedly an indigenous species. *Helicella virgata* has a remarkable distribution in a fossil state. It was common in the Pleistocene of Barnwell and Newquay, and a single example was found by Dr. Corner at Ilford. It was extremely abundant on the Neolithic hill wash at St. Catherine's Down, whilst a single example was found at Exedown, near Wrotham, and it was common at Brighton. Though it now occurs in countless myriads on the Chalk downs in the immediate vicinity of the hill-washes at Otford, Darenth, Reigate, Greenhithe, and Charing, no examples have yet been found in those deposits, and the only conclusion is that in some parts of the south of England it is a post-

* *The Naturalist*, 1897, pp. 75-6.
† A. Locard, "Variations Malac de bassin de Rhone," vol. ii, p. 226.

Roman introduction, possibly after the land had been cleared of forest.

Helicella barbara is known from two modern deposits, and from the Pleistocene of Newquay. On the Continent it is quite unknown in a fossil state, though it has been recorded from the Middle Pleistocene of Algiers. *Helicella cantiana* is a species of which one cannot speak with certainty as to its age in this country. It has been found at Otford, Exedown, and Reigate. Of these, the first is certainly post-Roman. It is, moreover, not improbable that its presence at Exedown may be due to burrowing for the purpose of hibernation. One of us has found *Helicella caperata* hibernating at a depth of 2½ feet. It is remarkable that *H. cantiana* should be absent from so many Holocene deposits in the neighbourhood of which it is now extremely abundant, and the conviction is forced on us that it is

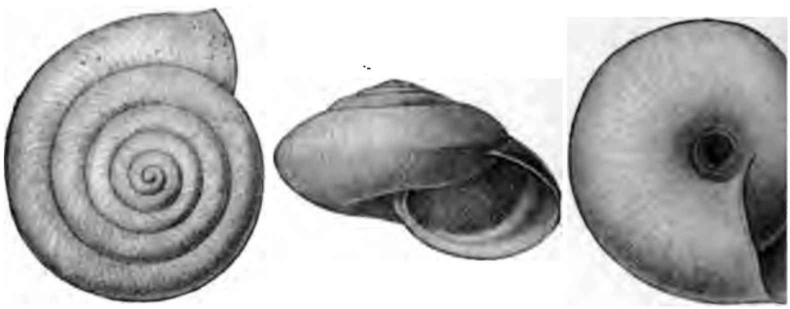


FIG. 36. *Hygromia umbrosa*, Partsch. (greatly enlarged.)

a late introduction. There can be no doubt that the area of distribution of *Helicella cartusiana* is diminishing. It is now restricted to East Kent and Sussex, and has lately been recorded from Norfolk; but that it was once common in West Kent is proved by its occurrence at Otford, Exedown, and Greenhithe. In the last deposit it is common, and the specimens are large, in this respect contrasting with those from Exedown and Otford, which are small. Elsewhere it is only known fossil, from Dover, and Felstead in Essex, though Mr. A. Bell has recorded it from Butley in Suffolk. This form has been considered to have been introduced by man in recent times, a view which is untenable in the light of the above facts.

Hygromia umbrosa was first recorded as an English fossil in 1897, and is only known to occur at Ightham. On the Continent it ranges through Southern Germany, Bohemia, Switzerland, Silesia, and the Carpathians, and, according to Mörch, is also found near Holstenberg in Denmark. In a fossil state it has only been recorded from the Middle Pleistocene of Leuben, near

Lommatzsch, and Robschütz, near Dresden, and from the Upper Pleistocene of Weimar. Four examples were taken at Ightham, two of which are immature. The occurrence of *Acanthinula lamellata* at West Wittering is of extreme interest. This species has been found fossil at Walthamstow, Felstead, Chignal St. James, Roxwell, Shalford, and Copford, all in Essex. At the present time it is not found living south of Staffordshire.

Helix aspersa may now be considered definitely not to be a modern introduction. Besides the localities mentioned in the table, it has been found in an undisturbed kitchen midden at Hastings by Mr. W. J. Lewis Abbott, and Mr. J. W. Flower notes*, that it is constantly found in British barrows in Wiltshire.

Helix pomatia is another of those species which have been considered a modern introduction, either by the Romans, the Norman monks, or even later. It may prove to be a pre-Roman introduction, but it is certainly not a later arrival. *Buliminus montanus* is a form which is apparently slowly dying out in this country. It is known from the Pleistocene of Barnwell and Clacton.

Pupa secale has only recently been recorded as an English fossil. It is interesting to note that it is now known from both the Holocene and the Pleistocene. *Vertigo levenensis*, Scott, was described in 1891† as *Vertigo concinna* from examples found in a Pleistocene deposit at Kirkland Leven. This name was afterwards changed to *V. levenensis*.‡ The species is near to *V. pygmæa*, but is very distinct, and has not yet been found elsewhere.

Paludestrina confusa is listed as a doubtful living species in south of England. It was restricted in this country to the Thames estuary, and since no living examples have been taken for some years it may be extinct. It is, however, quite possible that it may be found again in some of the numerous ditches in the marshes below Gravesend. Owing to its limited range it has been considered a modern introduction, but its geological history completely disproves such a view.

Vivipara clactonensis was first described in 1878,by S.V. Wood§ as *Paludina clactonensis* from two examples found by the Rev. O. Fisher, at Clacton, but he pointed out that a shell from the diluvium at Templehof near Berlin, called *P. diluviana* Kunth || very much resembled these specimens, and may be identical. Another example has since been found by Mr. A. Bell, whilst the Rev. J. W. Kenworthy has found numerous examples. That this species is distinct from *V. diluviana* is evident from a comparison ot the two forms. The late Professor C. L. F. Sandberger agreed

* J. W. Flower, F.G.S, "The Prehistoric Sepulchres of Algeria" (*Trans. Int. Cong. Prehist. Arch.*, 1868, p. 209).
† *Scottish Naturalist*, 1891, p. 53.
‡ *Op. cit*, p. 141.
§ 2nd supplement "Crag Mollusca," p. 69, Tab. 1, fig. 4 a and b.
|| *Zeitschrift Deutsch Geol. Geschellschaft*, Berlin, 1865, Tab.7, fig. 8.

with this view and considered that *V. lenzi*, *V. moisisovicsi*, and *V. brusinai* (Neumayer) from the *Congeria* Beds of Sclavonia are the nearest allies to *V. clactonensis*. Numerous examples have now been found at Swanscombe. *Neritina fluviatilis* has hitherto been unrecorded from the Pleistocene, though it is common in the Holocene. It is a very ancient form occurring in the Middle Miocene of Germany, hence its supposed absence from the ancient fauna of these islands was remarkable. It is now known to occur in abundance at Swanscombe, and it is probable that its absence from the middle terrace brickearths arises from the fact that they were in all likelihood deposited by a sluggish stream, whilst this species is an inhabitant of quick-flowing rivers.

Pyramidula ruderata has not hitherto been recorded from any locality south of the Thames. It is now known from both Swanscombe and West Wittering. Elsewhere it is met with at Copford, Clacton and Barnwell, and has been reported from Ilford and Grays.

G. SUMMARY.

Of the 139 species of non-marine Mollusca living in these islands, 129 occur in the south of England, whilst of the ten extinct forms, seven have been found in the same area, the missing species being :—*Eulota fruticum*, *Clausilia pumila*, and *Vertigo levenensis*.

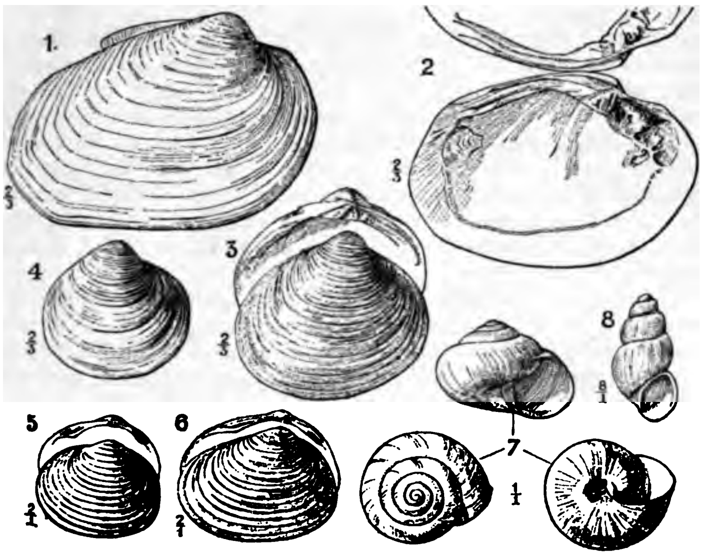
One form, *Acanthinula lamellata*, from the Pleistocene of West Wittering, is absent from both the Holocene and living faunas. The species which are only known from the Pleistocene and are still living are ten in number, viz. :—

Agriolimax lævis,	*Vertigo moulinsiana*,
Vitrea alliaria,	*Succinea oblonga*,
,, *glabra*,	*Limnæa glabra*,
Vertigo minutissima,	*Leuconia bidentata*,
,, *angustior*,	*Vivipara contecta*.

There are fifteen species which are known from the Holocene, and not from the Pleistocene, viz. :—

Vitrina pellucida,	*Vertigo pusilla*,
Vitrea pura,	*Vertigo substriata*,
Helicella cantiana,	*Balea perversa*,
,, *cartusiana*,	*Clausilia biplicata*,
Helix aspersa,	,, *rolphii*,
,, *pomatia*,	*Alexia myosotis*,
Buliminus montanus,	*Sphærium rivicola*.
,, *obscurus*,	

FIG. 37.—NON-MARINE MOLLUSCA EXTINCT IN THE BRITISH ISLANDS.



1, 2 } *Unio littoralis*
3, 4 } *Corbicula fluminalis*
5 *Pisidium astartoides*
6 ,, *amnicum*
7 *Eulota fruticum*
8 *Paludestrina marginata*

Omitting the Arionidæ, there are twenty-two forms now living in the district which have not been detected fossil, viz. :—

Testacella haliotidea,	*Hygromia revelata,*
,, *scutulum,*	*Helicodonta obvoluta,*
,, *maugei,*	*Helix pisana,*
Limax flavus,	*Melampus denticulatus,*
,, *arborum,*	*Amphipeplea glutinosa,*
Amalia sowerbii,	*Vivipara vivipara,*
,, *gagates,*	*Paludestrina jenkinsi,*
Vitrea lucida,	*Assiminea grayana,*
,, *excavata,*	*Sphærium ovale,*
Pyramidula rupestris,	,, *lacustre,*
Hygromia fusca,	*Dreissensia polymorpha.*

The six British species which have not been detected, either fossil or living, in the district are :—

Limax hedleyi,	*Vertigo alpestris,*
Geomalacus maculosus,	*Limnæa involuta,*
Pupa anglica,	*Unio margaritifer.*

H. CONCLUSION.

In the preparation of this and of our preceding papers, an immense amount of material has passed through our hands, and the utter uselessness, from a scientific standpoint, of the vast majority of the so-called varietal names has been impressed upon us. Examples, which on the Continent would be considered good species, and in this country varieties, are seen to be linked with the typical forms by gradational series, especially in such species as *Limnæa palustris*, *L. pereger*, *L. auricularia*, *Valvata piscinalis*, *Sphærium corneum*, *Pisidium amnicum*, and *Hygromia hispida*. We do not question the propriety of naming geographical races, but it is worse than useless to give names, too often non-descriptive, to trifling mutations of colour, shape and size.

We have already expressed the opinion that the Pleistocene molluscan fauna was a finer one than that of to-day, and this is shown by the fact that 113 species are known from the later Pleistocene, whilst there are only 103 forms represented in the Holocene, and this in spite of the fact that deposits of the latter age are far more numerous than those of the former. In this and our preceding papers sufficient evidence has been accumulated to enable us to speculate a little on the origin and duration in this country of the various constituents of our molluscan fauna. At the same time it must be borne in mind that such speculations are only tentative, and are derived from our present knowledge. It is quite within the range of probabilities that deposits may be discovered either in this country or abroad that will completely overthrow our conjectures; the future and our successors in this branch of investigation will verify or demolish our conclusions. Our evidence is derived from two sources, geological history and geographical distribution; the former is notoriously imperfect, and the latter can hardly be called an exact science, yet in spite of these defects the conclusions drawn from both so often agree that they may be considered fairly reliable.

Our non-marine Mollusca have reached this country from various sources. A large number are boreal, of these, some travelled hither along the now sunken land to the north of Scotland, whilst others may have journeyed hither through Siberia and the Continent; some have come from the south by the old land connection between England and the Continent; others, the so-called Lusitanian forms, have reached us from south-west Europe; a few species may be endemic.

The oldest inhabitants of these islands are *Paludestrina ventrosa* and *P. stagnalis*, which are known from the Pliocene of St. Erth. There are two other species which may be associated with them, *Bithynia tentaculata* and *Valvata piscinalis*. They all occur in the Pliocene of this country, and in the *Congeria* Beds of the Continent, hence they probably had their origin in the Aralo-Caspian basin.

Many years ago the late Edward Forbes called attention to the occurrence, in these islands, of a flora and fauna whose true home he considered to be in south-western Europe, and from this circumstance he called it the Lusitanian. We venture to think that this element is of greater importance than is commonly supposed. Besides the well-known instances of *Geomalacus maculosus* and *Helix pisana*, we would include in this group *Helicella virgata*, *H. itala*, *H. barbara*, *Testacella haliotidea*, *T. scutulum*, *T. maugei*, *Pupa anglica*, *Balea perversa*, *Pyramidula rupestris*, and even *Helix aspersa*.* That the Lusitanian group is of great antiquity in these islands is shown by the fact that the only helicoid known from the Coralline Crag, *Pyramidula suttonensis* (S. V. Wood), is a south-western form, having its nearest allies in *P. calathus* (Lowe) and *P. bifrons* (Lowe) from Madeira, and the same is also true of *P. rysa* (S. V. Wood), from the Red Crag of Walton and Waldringfield, whilst from the former locality have been obtained *Helicodonta lens* (Fer.), *Helix lactea* Müll., and *Hygromia incarnata* (Müll.), all of which belong to the same faunistic group. It is not until the later Red Crag of Butley that we have any evidence as to the existence, in these islands, of boreal species. Hence we conclude that the Lusitanian group is one of the oldest in these islands.

That this assemblage entered these islands from the southwest is manifest from their present distribution in these islands; it is noteworthy that, with the exception of *Testacella haliotidea*, none of the forms have been recorded from the Pleistocene of the Continent, though some are found in beds of that age in North Africa and in these islands. It is possible that *Helicodonta obvoluta* may also belong to this fauna, still as it is known from the Upper Pliocene of northern Italy, it may have reached these islands from the south at a later period, as its earliest record is from the Pleistocene of Grantchester, near Cambridge.

The true home of many species is, without doubt, in more northern latitudes, and hence this group is often spoken of as the boreal group. Many of these forms have a circumpolar distribution. Amongst others, we would particularise, *Vitrea radiatula*, *V. nitida*, *V. fulva*, *Punctum pygmæum*, *Vertigo pygmæa*, *Vitrina pellucida*, *Physa hypnorum*, *Unio margaritifer*, *Limnæa palustris*, *L. truncatula*, *Succinea elegans*, *S. oblonga*, *Cochlicopa lubrica*, *Pupa muscorum*, and *Sphyradium edentulum*. All these species are common to both sides of the Atlantic, and they are all known

* *Helix aspersa* has not yet been recorded fossil on the Continent, although occurring in the Pleistocene of Algiers, and may therefore be regarded, at present at all events, as a comparatively recent introduction.

We are inclined to suspect that the Mediterranean area, as a molluscan region, owes its existence as such to the facilities of trades affording a ready transport to these very species and their allies, which rapidly spread, as the *Opuntia* and Aloe have done, rather than that it ever formed originally a natural province.

from the English Pleistocene, whilst the last seven species are a known from the Pliocene. *Vallonia pulchella* is in all probabi a northern form, since it is circumpolar in its present distributi but its earliest record is from the Middle Miocene of Germany *V. subpulchella*, Sandb.).

The next group we can recognise is the Southern Group, a this in all probability is composed of species of various sour of origin. Some species have originated in south-eastern Euro whilst others probably came from the Alps. *Helix nemoralis* i typical southern form, attaining its maximum development southern Europe; though it is an ancient inhabitant of th islands, being known from the Red Crag of Butley as well from the Pliocene of Belgium (under the synonym of *He hæsendoncki* Nyst). To this Southern Group we would assi *Buliminus obscurus*, *B. montanus*, the four species of *Clausi* *Acicula lineata*, *Pomatias reflexus*, *Amphipeplea glutinosa*, *Vi para vivipara*, *V. contecta*, *Unio tumidus*, *U. pictorum*, a *Paludestrina confusa*. Lastly, there are several forms which m be endemic, or else their centre of origin is not far away. Th are *Hygromia fusca*, *Acanthinula lamellata*, *Vitrea excava* *V. alliaria*, and *Azeca tridens*. All these forms are as quite unknown in a fossil state on the Continent, and thou this is true of the two first species in this country, the remain are all known from the Pleistocene, and their distribution is su as to lend great support to the view that they have had th origin in these islands.

It may be remarked that many of these views are in agr ment with those recently expressed by Dr. R. F. Scharff,* a though we cannot endorse the geological views expressed, the same time yet we venture to think that the work is worthy more consideration than it has received. It is a matter of c gratulation that Pliocene and post-Pliocene geology is r receiving more attention than was formerly the case. Evide on all sides and from varying standpoints is fast accumulati Old theories have been discarded, and in their place new id reign, perchance to suffer a similar fate in the future. Thus i with the views we have expressed: tentative they must be, final word unknown to science. In conclusion, we may quote words of the Rev. R. Boog Watson, whose monumental work the Gastropoda of the Challenger Expedition is so well kno "No one can doubt that the history of species is a record we only beginning to decipher, and that here is work for every of us to do. Worthier work by far than the mere multiplica of species, or the sub-division of genera, or the reductior scientific nomenclature through constant change to a Babel confusion of tongues."

Since these conclusions as to the constituent elements of

* "History of the European Fauna," London, 1899.

British non-marine molluscan fauna were written, the concluding portion of Mr. J. W. Taylor's first volume on the "Land and Freshwater Mollusca of the British Isles" has appeared, and his views on the subject call for brief notice. He recognises an eastern and a western province, and, rejecting a northern origin for any of the species, advances the hypothesis derived evidently, though he does not say so, from a consideration of the past history of the human inhabitants that a weaker assemblage of molluscan representatives has been displaced and driven out by a stronger invading fauna. "This waning western fauna is exemplified by *Helix fusca. Helix lamellata, Pupa anglica, Succinea oblonga, Unio margaritifer*, etc." This ingenious theory, however, ignores the evidences of geology, the two last of the species cited not having been found fossil at all in the very region from which they are presumed to have been ousted, whilst, from their present distribution, they cannot be called western; one of them being almost circumpolar. It, moreover, neglects to take into consideration the inevitable effect of the glacial period. That the distribution of some species has been diminished, whilst others have become extinct is true, but the true explanation has yet to be given. It probably arises from several causes, and, in our opinion, is not due to the superiority of higher forms over those less specialised.

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THE PLEISTOCENE FAUNA OF WEST WITTERING.

By J. P. JOHNSON.

(*Read March 1st, 1901.*)

AT West Wittering, a small village at one extremity of Bracklesham Bay, there is exposed on the foreshore at low tide one of the most interesting Pleistocene deposits in Britain. The buried river channel, in which it occurs, was described by Mr. C. Reid, F.R.S.,* in 1892, when he recorded from it no less than 60 species of plants—which he has recently increased to 94†—and 39 of Mollusca. Two of the plants, *Najas minor* (Allione) and *N. graminea* (Delile), are not now living in this island, and one, *Potamogeton trichoides* (Cham.), is no longer an inhabitant of southern England. Of the Mollusca, *Corbicula fluminalis* (Müll.) has died out in all Europe, but still survives in parts of Africa and Asia; *Paludestrina marginata* (Mich.), though extinct in the British Isles, still lives on in the Continental rivers; and *Succinea oblonga* (Drap.) no longer inhabits the south of England, though it was very common there during the Pleistocene period, and even struggled on, at Battersea, into historic times. Only two vertebrates have hitherto been obtained from this deposit, viz., elephant and rhinoceros, but the presence of a rodent was inferred from the occurrence of gnawed nuts.

When I examined the district in the summer of 1899, there 'as only one small fossiliferous exposure—a little to the east of ıe solitary tree on the edge of the cliff. Resting on an ochreous nt gravel were buff-coloured loams, capped by peaty earth; ›m this point to the foot of the low cliff, the beds were hidden modern sand and shingle. No specimens of *Corbicula minalis* were obtained, but *Paludestrina marginata* was :remely abundant, and the deposit yielded no less than fourteen ecies of Mollusca not in Mr. Reid's list, together with bones of rog. During Easter of 1900 I again visited the locality, and uld find no trace of the above-mentioned exposure, but farther the west a far more extensive section was uncovered, owing to e beach having been swept on to the top of the cliff. The ccession was much the same as that previously noted, but, ıile the basal gravel was hidden by sand, higher beds were posed. It was as follows:—

Stony loam, forming cliff.
Marine shingle (traces).
With *Corbicula fluminalis*. { Mottled estuarine loam.
Peaty mud with plant remains. } With land and
Buff-coloured loam. } freshwater shells.

* "Pleistocene Deposits of Sussex Coast." *Q.J.G.S.*, vol. xlvii (1892).
† "Origin of British Flora" (1899).

At Whitsuntide the whole series was shown, but only in patches.

When the beds are not well exposed, one must be careful not to confound the adjacent Recent alluvium with the Pleistocene.

As the result of a careful examination of a large quantity of material from the *Corbicula*-beds, I am able to record numerous additions to the Pleistocene fauna of the neighbourhood.

In washing for the smaller forms I have come across a number of Ostracoda, but they are all referable to our largest existing species, *Herpetocypris reptans* (Baird).

It is in the non-marine Mollusca that the greatest interest lies. I have already alluded to the three locally extinct shells recorded by Mr. Reid. To these I am able to add another continental species, *Pyramidula ruderata*, represented by a single, but very fine, specimen, and a small helicoid land-shell, *Acanthinula lamellata*, which at the present day is limited to the north of England, and Scotland. The latter mollusc was already known to have extended farther south in pre-historic times, specimens having been found in the Pleistocene of Barrington and Copford, and in the Lea Valley alluvium; but one would hardly have expected it to turn up on the south coast, and in comparative abundance, too!

Pisidium milium is noteworthy, as at the time it was found it was new to the Pleistocene; but I have since recorded it from Ilford.*

Paludestrina confusa is another interesting shell; it formerly existed in the Thames, to which river it was confined, but it is now thought to be extinct in Britain.†

Planorbis glaber is another of those molluscs which were once so abundant, but which are now very nearly exterminated.

Limnæa glabra is noteworthy, as when found it was unknown in the fossil state, but a single example has since been recorded from the Palæolithic drift at Ilford.

Altogether I am able to add 26 land and freshwater shells. Many of these exhibit great variation, but I cannot go into that question here.

Looked at generally, the earlier terrestrial Mollusca of West Wittering constitute a type of fauna very different to that now inhabiting the neighbourhood, even when those that have become extinct in southern England are left out of consideration. This is mainly because the dry calcareous soil formed by the superimposed loam, while inducing the immigration of new forms, such as the chalk-loving *Helicellæ*, is totally unsuited to the majority of those species that lived on the damp, clayey surface of older times.

* "Additions to Palæolithic Fauna of Uphall Brickyard, Ilford." *Essex Naturalist*, vol. xi (1900).

† See Kennard and Woodward. "Notes on Paludestrina jenkinsi and P. confusa." *Proc. Malacological Soc.*, vol. iii (1899).

Turning to the estuarine bed, the lower part contains a few narine shells, to which I can add 5 species. On one occasion small colony of *Scrobicularia plana*, from the midst of which I btained the mammalian tooth referred to below, was exposed, he shells still remaining in the position of life. *Corbicula luminalis* also occurs in this bed, together with occasional pecimens of *Planorbis marginatus* and *Bythinia tentaculata*.

A complete list of the Mollusca which I have found is given at he end of the paper, the new records being indicated by an asterisk *). Those that occur in the estuarine bed only are marked hus (†), and those common to both (‡). The collection in the Museum of Practical Geology, which I have been enabled to xamine through the courtesy of Mr. E. T. Newton, F.R.S., ontains one species, *Pyramidula rotundata*, which is unrepreented in mine. It is included in the above-mentioned list.

My vertebrate remains comprise the common frog (*Rana emporaria*, L.) and the water-vole (*Microtus amphibius*, L.), both of which are additions to the fauna. The former is represented by several bones, and the latter by teeth from the peaty earth. also found a molar of the latter in the estuarine loam.

Neither the marine shingle, of which there are only traces, nor the overlying stony loam has yielded fossils.

The relation of the fossiliferous beds of West Wittering to hose of other parts of the Hampshire Basin has been made clear by Mr. C. Reid in the paper quoted. Their relation to the Pleistoene sub-divisions in other districts is, however, not so certain, nd, as one might have expected, the West Wittering fauna hrows no light on this question. I have endeavoured* to effect solution by comparing the Pleistocene deposits of that part of e Hampshire Basin, which lies between Chichester Channel and righton, with those of the Valley of the Wandle and of the hames Basin generally; but it is for others to judge whether I ave been successful or not.

List of Mollusca.

griolimax agrestis, L.
,, *lævis*, Müll.
itrea crystallina, Müll.
,, *nitidula*, Drap.
,, *nitida*, Müll.
,, *fulva*, Müll.
hyradium edentulum, Drap.
nctum pygmæum, Drap.
ramidula ruderata, Stud.
,, *rotundata*, Müll.
gromia hispida, L.
**Acanthinula aculeata*, Müll.
* ,, *lamellata*, Jeff.
Vallonia pulchella, Müll.
**Helicigona arbustorum*, L.
Helix nemoralis, L.
Cochlicopa lubrica, Müll.
**Pupa cylindracea*, Da C.
,, *muscorum*, L.
**Vertigo antivertigo*, Drap.
* ,, *pymæa*, Drap.
* ,, *moulinsiana*, Dup.

* "Pleistocene Geology in Hants Basin and Thames Valley" (1901), and "Palæolithic in Valley of the Wandle" (1900). *Science Gossip* (n.s.), vol. vii, pp. 233-234 and pp. , 177, 221.

LIST OF MOLLUSCA.—*continued.*

* *Vertigo angustior*, Jeff.
* *Clausilia bidentata*, Strom.
* *Succinea putris*, L.
,, *elegans*, Risso.
,, *oblonga*, Drap.
Carychium minimum, Müll.
Ancylus fluviatilis, Müll.
Velletia lacustris, Müll.
Limnæa auricularia, L.
,, *pereger*, Müll.
,, *palustris*, Müll.
* ,, *truncatula*, Müll.
* ,, *stagnalis*, L.
* ,, *glabra*, Müll.
* *Planorbis glaber*, Jeff.
,, *nautileus*, L.
,, *carinatus*, Müll.
‡ ,, *marginatus*, Drap.
* ,, *vortex*, L.
,, *spirorbis*, Müll.
,, *contortus*, L.
* ,, *fontanus*, Lightf.
* *Physa fontinalis*, L.
* *Physa hypnorum*, L.
Paludestrina confusa, Frau.
‡ ,, *ventrosa*, Mont.
† ,, *stagnalis*, Bast.
,, *marginata*, Mich.
‡ *Bythinia tentaculata*, L.
* ,, *leachii*, Shepp.
Valvata piscinalis, Müll.
,, *cristata*, Müll.
†* *Littorina rudis*, Maton.
†* ,, *littorea*, L.
†* ,, *obtusata*, L.
‡ *Corbicula fluminalis*, Müll.
Sphærium corneum, L.
Pisidium amnicum, Müll.
,, *pusillum*, Gmel.
* ,, *milium*, Held.
† *Cardium edule*, L.
† *Macoma balthica*, L.
† *Scrobicularia plana*, Da C.
†* *Ostrea edulis*, L.
†* *Mytilus edulis*, L.

[Since writing the above my friend, G. White, has obtained teeth of the pike (*Esox lucius*, L.) from this deposit. I am also able to add three more non-marine Mollusca, viz.: *Planorbis* (*Segmentina*) *lineata*, Walker, *Vertigo pusilla*, Müll, and *Arion ater*, L. I have also a single vertebra indistinguishable from certain of the peculiar vertebrae of the eel (*Anguilla vulgaris*, Turton), to which fish I would therefore refer it, though with slight hesitation.]

EXCURSION TO WOKING.

SATURDAY, SEPTEMBER 21ST, 1901.

Director: R. S. HERRIES, M.A., F.G.S.

Excursion Secretary: J. W. JARVIS, F.G.S.

(*Report by* THE DIRECTOR.)

THE object of this excursion was to examine the works of widening the South Western Railway's line, west of Woking station, which the members were enabled to do by kind permission of the Company.

Leaving Waterloo at 1.20, the party arrived at Woking at 2.15, where they were met by Mr. E. A. Ogilvie, of the engineering staff of the South Western Railway, who not only gave the members every assistance during the afternoon, but was very assiduous in searching for sharks' teeth in the cutting. The party got on to the railway at the east end of the cutting, about a mile west of Woking station, formerly called on the map Goldsworthy, but now Goldsworth cutting. At this point the junction of the Middle and Lower Bagshot was exposed, a stiff clay resting on yellow sand. Proceeding a little farther to where a good section of the beds exposed by the new works could be seen, the Director explained that this cutting had been described in detail by Prestwich in 1847, in his paper on the Bagshot Sands (*Quart. Journ. Geol Soc.*, vol. iii, p. 382), and it would be seen that this description of what was seen when the line was originally made could not be improved on, now that the beds were once more freshly exposed. The Director only differed in a matter of interpretation, namely, in thinking that there was no Upper Bagshot represented in the section, whereas, Prestwich gives a few feet in his figure. The occurrence of the bed of pebbles on Hook Heath, described by Mr. H. W. Monckton and the Director (*Proc. Geol. Assoc.*, vol. xi, p. 16), seemed to preclude the possibility of the occurrence in the cutting of the pebble-bed, now generally recognised as the junction between the Upper and Middle Bagshot, though no doubt pebbles occurred at the top derived from this pebble-bed, or, perhaps, from one of the lower and less persistent ones, which are occasionally found towards the top of the Middle Bagshot. Thus we find that the beds exposed in the cutting practically represent the Middle Bagshot, which is the equivalent in age of the Bracklesham of the Hampshire basin. The section is about 45 feet in thickness. Prestwich's section is as follows :

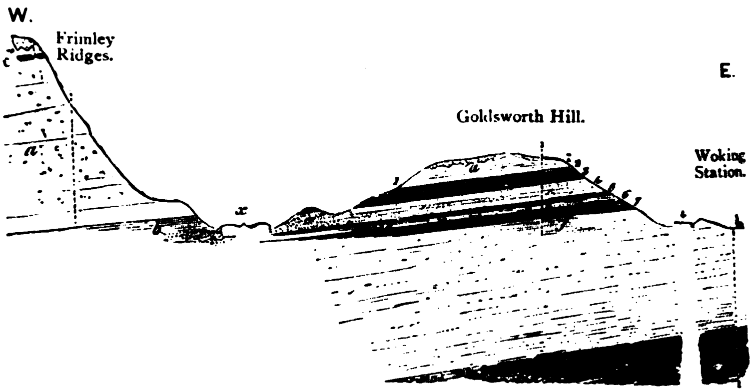

FIG. 38.—SECTION FROM FRIMLEY RIDGES TO WOKING STATION—*Prestwich.*

		Feet.
a.	*Upper Bagshot Sands.*	
	Yellow and light ochreous siliceous sands. Sandstone concretions at o.	150
b.	*Middle Bagshot Sands.*	
1.	Coarse greenish sand with a few flint pebbles ...	2
2.	Foliated [laminated] sandy clays of various shades of brown	11
3.	Grey clay with traces of lignite	1
4.	Green sand; upper part light-coloured and clayey, the lower part pure and dark-coloured. Numerous teeth and bones of fishes and turtles, *Turritella sulcifera* and *Venericardia planicosta*, &c.	16
5.	Compact lignite	1
6.	Light-coloured compact sandy clay, passing downwards into dark grey clay. The upper part is irregularly pierced with green sand-tubes ...	6
7.	Light and dark brown and liver-coloured very compact foliated [laminated] clays with traces of vegetable impressions...	8
c.	*Lower Bagshot Sands.*	
	Light yellow siliceous sands with irregular light-coloured argillaceous beds. Traces of vegetable impressions	130
d.	*London Clay.*	
x	Interval of three miles.	
†	Interval of quarter of a mile.	

The section is very similar to that of the cutting at Shapley Heath, near Winchfield station, visited by the Association in July, 1900 (*Proc. Geol. Assoc.*, vol. xvi, p. 519), and the other sections mentioned in that report. The persistence of the green sand bed and the clay beds above and below it throughout the district was remarkable.

The President remarked on the confusion introduced into geological nomenclature by the use of the terms Upper, Middle, and Lower Bagshot in the London and Hampshire basins for beds which were not of the same age. It would be better to speak of Barton, Bracklesham, and Bagshot.

The Director agreed, especially as this plan would necessitate the so-called "Upper Bagshot" of Hampshire going with the series above under one of its many local names.

Attention was particularly directed to the tubes of green sand penetrating the underlying lignite and piercing the clay (bed 6), as described by Prestwich, and the lignite bed itself was carefully studied. There were also found some masses of *Teredo*-bored drift wood in bed 4. The members then searched the sloped face of the green sand (bed 4) for fossils, and a number of teeth were found, but no shells, which is curious, considering that they were recorded by Prestwich, and that they are so abundant at Ascot and other exposures of the same bed. The following have been kindly determined by Mr. E. T. Newton, F.R.S.

FISH FROM GOLDSWORTH CUTTING, WOKING, BRACKLESHAM SERIES (MIDDLE BAGSHOT).

Odontaspis macrota Ag.	*Otodus trigonalis* (?) Jaek.
" *elegans* Ag.	*Galeocerdo* sp.
" *cuspidata*, Ag.	*Ætobatis* sp.
Lamna vincenti, Winkl.	*Myliobatis* sp.

This list may be compared with that given in the report of the Winchfield excursion (*Proc. Geol. Assoc.*, vol. xvi, p. 521) and with that given by Prestwich (*Quart. Journ. Geol. Soc.*, vol. iii, p. 390; reprinted *Mem. Geol. Survey*, vol. iv, p. 599).

Leaving the railway at the bridge over the middle of the cutting, the party came down the hill and visited the Lower Bagshot sand-pits, near the Portsmouth Railway, in which occurs the bed of marine fossils noted on a previous excursion, to Woking (*Proc. Geol. Assoc.*, vol. xv, p. 187, and see *Quart. Journ. Geol. Soc.*, vol. xlviii, p. 487, and proc., p. 188). Numerous casts were observed. An adjournment was then made to the Railway Hotel for tea. After votes of thanks to Mr. E. A. Ogilvie, the Railway

Company, and the Director, the members proceeded
station and left for London by the 6.30 train.

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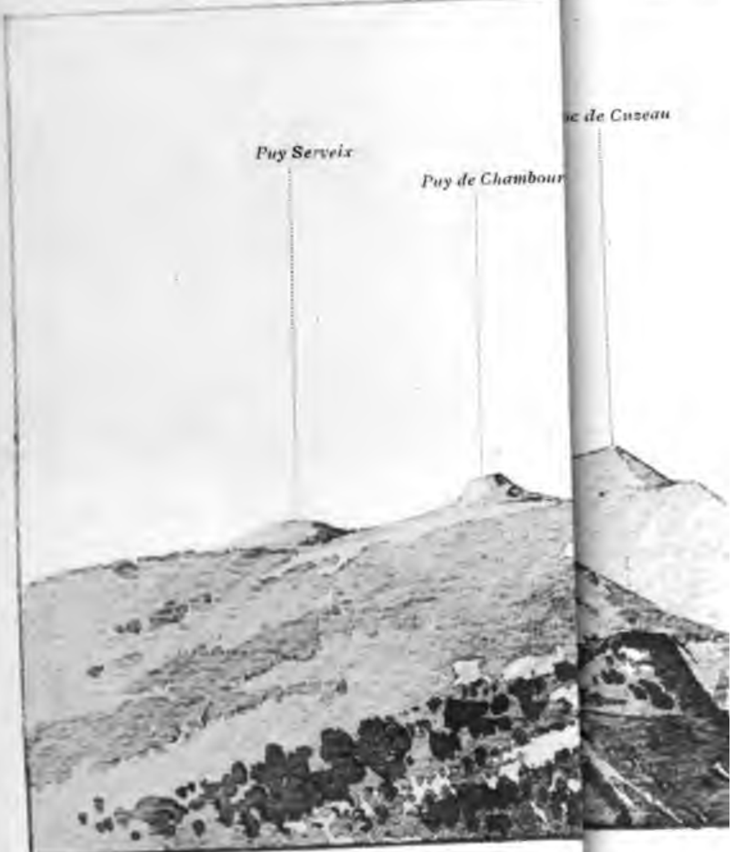
,, *nemoralis*, Linn.	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	B.	×	×	×	×	×	×
,, *hortensis*, Müll.	×	...	×	...	...	...	...	×	...	G.	...	×	×	×	...	...	×	...	...	...	×	...
Assiminea grayana, Leach	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pomatias reflexus (Linn.)	×	...	×	...	...	...	×	×	×	×	...	×	×	×	...	...	×	×	...	...	×	...
Acicula lineata (Drap.)	×	...	...	...	...	...	...	...	×	...	...	...	...	...	×	B.	...	×	...	...	...	...
Neritina fluviatilis (Linn.)	×	×	...	...	...	×	...	...	...	...	P.	...	...	×	...	...	...	...	×	...	...	...
B. *PELECYPODA.*																						
Dreissensia polymorpha (Pall.)	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Unio littoralis (Lam.)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	...	...	...
,, *pictorum* (Linn.)	×	...	...	...	...	...	...	...	...	...	...	...	...	W.	...	...	...	...	×	...	...	...
,, *tumidus*, Retz.	×	...	...	...	...	S.	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...
,, *margaritifer* (Linn.)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Anodonta cygnæa (Linn.)	×	...	...	...	...	×	...	...	...	...	...	...	...	×	×	...	...	...	...	...	...	...
Corbicula fluminalis (Müll)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	×	×	×
Sphærium rivicola (Leach)	×	E.	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...
,, *corneum* (Linn.)	×	×	...	...	×	×	...	...	..	G.	×	...	...	...	×	...	...	...	×	×	...	×
,, *ovale* (Fér.)	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, *lacustre* (Müll.)	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pisidium amnicum (Müll.)	×	×	...	...	...	...	...	...	...	×	×	...	...	×	×	×	...	...	×	×	...	×
,, astartoides (Sandb.)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	...	...	...
,, *pusillum* (Gmel.)	×	×	...	...	×	...	...	...	...	×	×	...	...	...	×	×	...	×	×	×	×	×
,, *nitidum*, Jenyns.	×	...	...	...	...	...	...	...	...	×	×	...	...	...	×	...	...	...	...	...	...	...
,, *fontinale* (Drap.)	×	×	...	...	...	×	...	...	...	×	×	...	...	...	×	×	...	...	×	...	×	×
,, *milium* (Held.)	×	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	×	...	...
Totals { Living 138	129	39	26	19	22	45	29	30	34	52	52	35	29	41	45	29	27	14	47	56	38	27
Totals { Extinct 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	1	...	6	3	1	2

7 Species no longer living in England occur in the Pleistocene.
10 Species now living in the South of England have been found in the Pleistocene only.
15 Species now living in the South of England have been found in the Holocene only.
† 22 Species now living in the South of England have not been found fossil at all.
† This last does not include the *Arionidæ*.

B.—On the authority of Dr. H. P. Blackmore.
E.—On the authority of C. Evans.
R.E.—On the authority of R. Etheridge.
G.—On the authority of Dr. J. E. Gray.
M.—On the authority of Prof. J. Morris.
P.—On the authority of J. Pickering.
S.—On the authority of F. C. J. Spurrell.
W.—On the authority of Dr. S. P. Woodward.

Mont Dore."



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wing by M.

[G EXCURSION TO THE AUVERGNE.

AUGUST 17TH TO AUGUST 30TH, 1901.

s: M. MARCELLIN BOULE, M. J. GIRAUD, M. PH. GLANGEAUD.

Excursion Secretary: D. A. LOUIS.

C. G. CULLIS and D. A. LOUIS, with notes and original contri-
ions by M. Giraud, M. Glangeaud, and M. Pierre Marty.)

PREFATORY REMARKS.

eological excursions in the Auvergne and neighbourhood, ning the subject of this report, occupied fourteen days. : eight of these were spent in the Department of the ôme, and during this period the party worked under nce of M. Ph. Glangeaud, who conducted the excursions st, third, fourth, fifth, and sixth days, and of M. J. Giraud, rtook the direction of the second and eighth days. The day was directed by M. Giraud and M. Glangeaud y. In drawing up the report of this part of the the writers have been greatly assisted by notes tributions, kindly supplied by both of the Directors; is to be understood that the geological matter in ts of the first, third, fourth, fifth, sixth and part of the days is mainly due to M. Glangeaud, while that of d, eighth and part of the seventh days is to be credited in to M. Giraud.

g the remaining six days, of which four were passed in l, one in Corrèze, and one in the Puy-de-Dôme, the of the party was, with great kindness, undertaken by ellin Boule. The report of this latter half of the is based upon notes taken during its progress by s, and by Mr. E. E. L. Dixon.

two panoramas which accompany the report are from our drawings by M. Eusébio, sent by M. Glangeaud, ddition, lent the photographs for Plates XIII and XIV, supplied drawings for many of the figures which occur t; figures 39, 40 and 49 are reproduced, with permission, Monograph on the Volcano of Gravenoire. Figures 41 re from sketches by M. Giraud, and the three beautiful ns of fossil leaves are from original drawings made for t by M. Pierre Marty.

REPORT.

ty of members of the Geologists' Association and their ogether numbering thirty, and including five ladies, left n the evening of *Thursday, August 15th*, 1901, for the t.

Travelling *via* Newhaven and Dieppe they reached Paris early on the following morning. The drive across Paris from the Gare St. Lazare to the Gare de Lyons, in the fresh morning air, was an agreeable change from the confinement of the night's journey. At the Gare de Lyons they were joined by a few members who had travelled in advance, and by a representative of M. Desroches, the agent, to whose care had been entrusted the travelling and housing arrangements of the party while in the Auvergne. The journey southwards from Paris occupied the whole of the day, but its tedium was much relieved by the facilities for communication afforded by the corridor carriage which the party occupied, and by numerous altercations arising from the defence of the reserved compartment against aggressive intruders. Late in the afternoon the first glimpse was obtained of the distant volcanic hills, and these momentarily growing clearer were watched with keen interest during the remainder of the journey. Clermont Ferrand was reached shortly after six o'clock M. Desroches was in attendance to welcome the somewhat jaded travellers, who were soon conveyed from the station to the Grand Hotel de la Poste, where it was ascertained that the casualties of the journey had not been serious, one member and one bag, only, being missed.

M. Glangeaud and M. Giraud joined the party at the hotel and were welcomed on behalf of the members by the President, Mr. Whitaker. After dinner M. Glangeaud announced the programme for the following day and distributed a daintily illustrated summary from which each member could gather the chief facts of geological interest to be studied. This practice he followed on all occasions when acting as Director. He also announced that many invitations had been offered by public bodies and others to the members of the party, and these kindnesses, having been duly acknowledged, were accepted on the understanding that they should not interfere with the working programme.

EXCURSION TO THE VOLCANO OF GRAVENOIRE AND TO THE MINERAL SPRINGS OF CLERMONT AND ROYAT.

Director: M. PH. GLANGEAUD.

At six o'clock on the morning of the *first day, August 17th*, the members began to be on the move, and shortly afterwards, in brilliant weather, the work as set forth in the programme was commenced. Proceeding from Clermont to Royat the party saw rising before them the volcano of Gravenoire, which was to be the object of their morning's study. Before commencing this work in detail, however, the more prominent physical features of the region were pointed out by the Director, and the geological causes explained to which these features owe their origin: Standing at Royat and looking eastwards, the members saw stretching before them the great plain of the Limagne, formed essentially of Tertiary sediments. Looking westwards they saw running to right and left, and sloping steeply up from them, the great furrowed escarpment of the ancient crystalline rocks against which the faulted Tertiary sediments abut; and grafted as it were upon the lower slopes of this escarpment they saw the tree-clad and somewhat conical hill whose structure and geological details they were about to investigate.

The more prominent facts relating to the geology of this volcano were set forth in the summary which M. Glangeaud had presented to the members on the previous evening, and of which the following is a somewhat free translation.

> * The volcano of Gravenoire is situated upon the western border of the Limagne, and is backed by the elevated crystalline region which supports the Chain of Puys. It overlooks, to the north and to the south, two valleys considerably more than a thousand feet deep, which have been scored in the granitic escarpment which dominates the Tertiary basin—the valleys of the Tiretaine and Artière.
>
> The volcano is installed upon the great western boundary-fault of the Limagne, which has produced the escarpment, and along which the Oligocene strata, inclined and folded in Mio-Pliocene times, are let down. Through this fracture, widened into a fissure, issued all the materials forming the present cone, and the lava-flows which extend from it, on the one hand towards Royat, on the other towards Boisséjour.
>
> Upon the parallel faults by which the Tertiary strata, and the lavas of the ancient (? Miocene) volcano of Charade have been depressed in successive steps towards the centre of the Limagne, there have arisen, in the vicinity of Beaumont, at least three little volcanoes. Of these, two have yielded lava-flows, one, the cone of Mont Joly, sending a stream towards Clermont-Loradoux, the other, the cone of Beaumont, sending a stream towards Aubière. (Fig. 39.)
>
> The pressure exerted by the faulted masses at the foot of the crystalline plateau, was doubtless one of the principal causes which led to the issue of these lavas. They ascended along faults which had been developed at the close of the Miocene period. The genesis of these volcanoes recalls, therefore, that of the analogous volcanoes described by Keilhack

* "Monographie du Volcan de Gravenoire," Bull. des Services de la Carte Géol. de la France, &c. 1901.

and Thoroddsen in Iceland, and of the volcanoes of Latium as explained by Portis.

The lava-currents from Gravenoire and from the volcano of Beaumont flowed along valleys of Upper Pliocene age, filling them up more or less completely. The floors of these

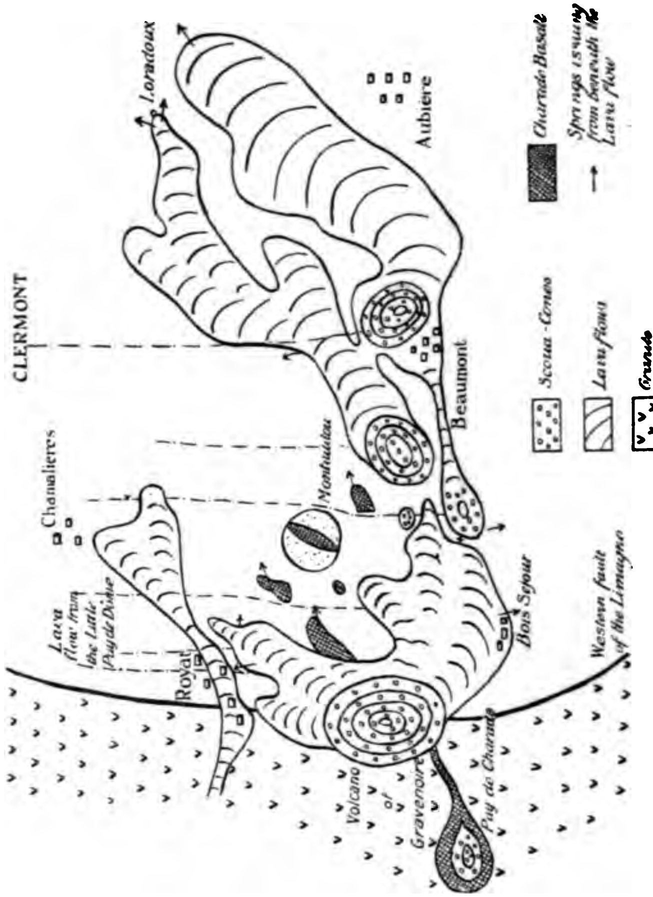


FIG. 39.—MAP OF THE VOLCANOES OF GRAVENOIRE, CHARADE, AND BEAUMONT.

ancient valleys, covered with alluvium surmounted by the basalt-flows, are still traversed by streams, and it is they which give origin to the springs of Boisséjour, Beaumont, St. Jacques and Loradoux. Since the time of the emission of these lavas, erosion has dug on either side, the valleys of the Tiretaine and the Artière, between which the basaltic sheets now form an elevated plane sloping gently down to the Limagne.

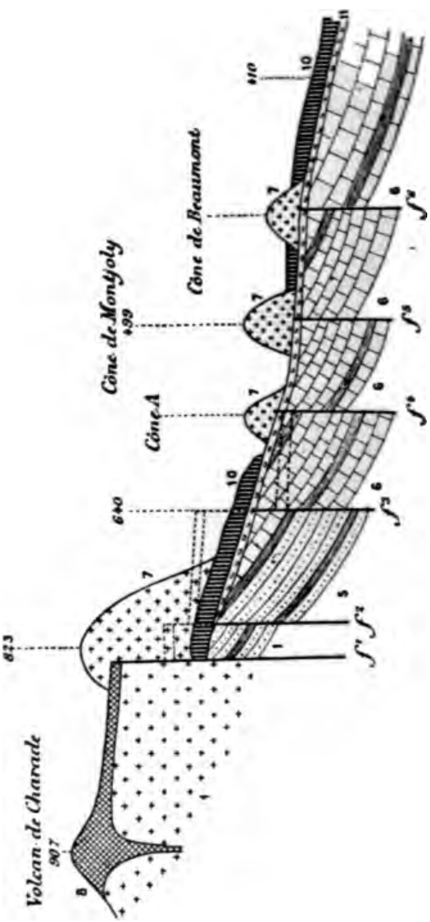
The metamorphism produced by these lavas varies according to the materials with which they have come into contact. Sometimes, as in the baking of clays and their conversion into veritable "brick", and the rubefaction of sands and arkoses, the changes are not profound; but, at other times, as in the absorption and recrystallization of blocks of limestone and masses of crystalline rocks brought up from below, the changes have involved a more or less complete chemical and mineralogical reconstitution. The alteration of quartzose or quartzo-felspathic rocks has often led to the production of augite, andesine, sillimanite, spinellids, and zeolites. The conversion of limestone into garnet, wollastonite, augite, anorthite, etc., recalls that of the Italian volcanoes of Latium and Somma. The action of volcanic vapours upon blocks torn from below has resulted in the formation of such minerals as hematite, magnetite, pseudobrookite, augite, aegerine-augite, biotite, labradorite, anorthoclase and apatite. This assemblage of minerals is analogous with that in the tuffs of Nocera, Vesuvius, and Santorin. Volcanic activity has not yet entirely ceased in the district. It still continues to manifest itself in the existence of numerous hot springs which emerge along the outcrops of the so-called volcanic or hydrothermal faults (springs of Royat and Clermont). Moreover, the exudation of bitumen from these faults is not uncommon (Puy de l'Ecorchade, Puy Chateix); and exhalations of carbon dioxide, either alone (mofettes) or in association with heated waters, are very abundant.

The eruptions of the volcanoes of Gravenoire and Beaumont took place in early Quaternary times.

During the morning the members saw for themselves all the ading facts and many of the details of this volcano, which otwithstanding its smallness is one of the most interesting in the uvergne. They ascended its eastern slopes to a point whence a ne view of the plain of the Limagne was obtained, and a glimpse the volcano of Charade, which is perched behind Gravenoire on a higher part of the sloping escarpment of the crystalline cks. During the ascent a number of quarries and natural posures were visited, and in these the lavas and dark-coloured hes of which the hill is composed were seen. Sometimes they ere fresh, sometimes characteristically altered by fumarolic tion; their gentle slope outwards and downwards from the mmit was often plainly visible, and in one exposure the ashes, hich are quarried for "gravel", were seen resting directly upon e underlying granite.

Descending then to the level of the plain, the road passing rough Beaumont was followed, in order that a closer inspection ight be made of the little eruptive cones and lava-flows in that cinity. It was here, through the courtesy of M. Mourlevat, who kindly permitted them to enter his garden, that the members saw the remarkable section illustrated in Plate XII. It is a cliff-like termination of a basaltic flow from Mont Joly, one of these tiny cones; the lava lies in the hollow of a little valley of Upper

FIG. 40.—DIAGRAMMATIC SECTION OF THE VOLCANOES OF CHARADE, GRAVENOIRE, AND BEAUMONT.

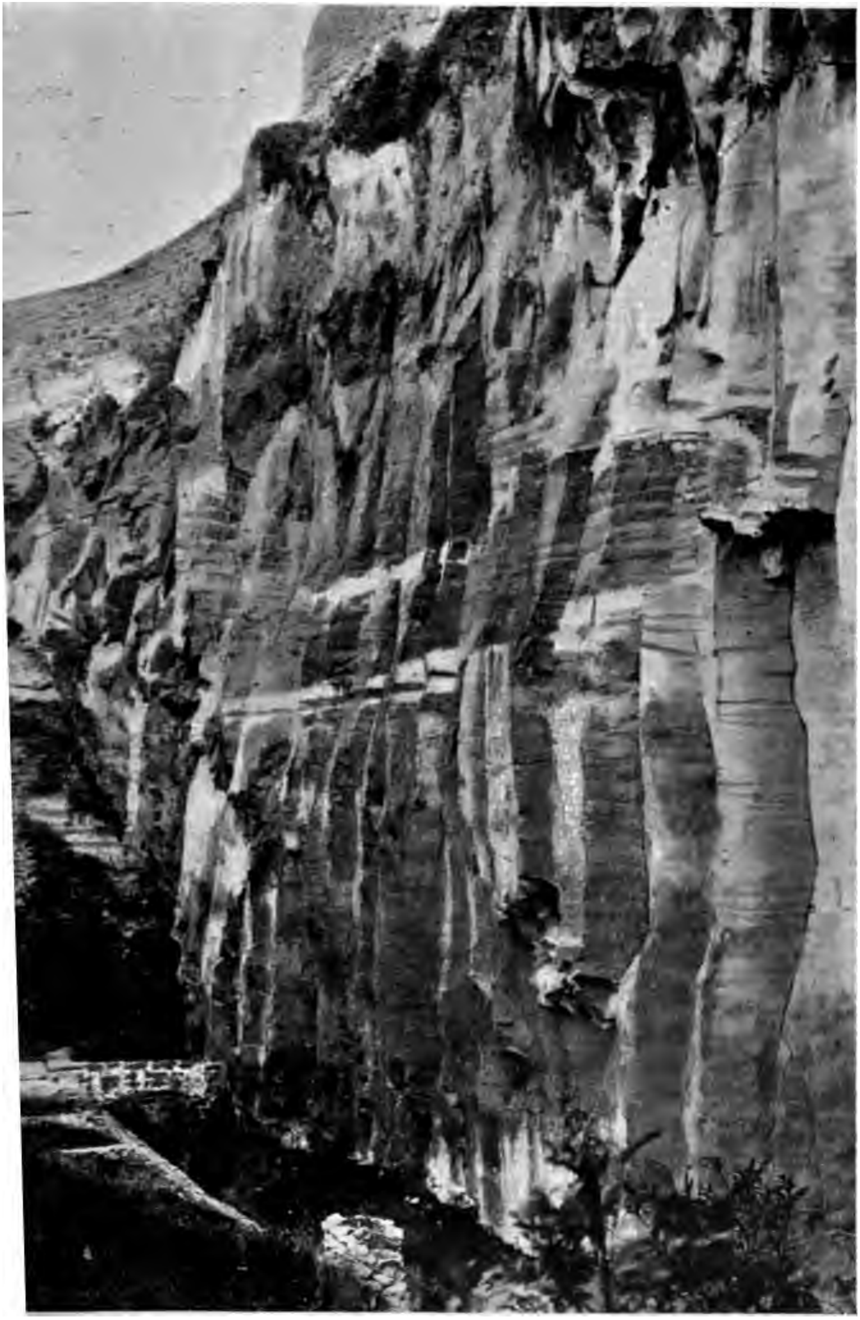


1. Granite; 5. Arkoses and clays (Upper Sannoisian); 6. Marls, marly limestones, and arkoses (Stampian); 7. Scoria-cones; 8. Lava-flow from the Charade Volcano; 10. Lava-flow from Gravenoire and from the Cones of Beaumont; 11. Sub-basaltic Alluvium (Lower Quaternary); f^1 f^8 Volcanic and hydro-thermal faults.

Pliocene age, and rests upon alluvium which carpets the valley-floor and through which a stream of clear water, filtering its way, emerges into the garden at the foot of the lava-wall.

From Beaumont the party returned to Clermont, where, having lunched, they appreciated the short rest which their indefatigable Director allowed before resuming work.

In the afternoon a visit was paid to the famous encrusting



QUATERNARY VALLEY FILLED BY A COLUMNAR FLOW OF BASALT FROM MONT JOLI, NEAR CLERMONT-FERRAND.

(From a Photograph by Professor Armstrong.)

springs—the so-called petrifying springs—of St. Alyre. Owing to the large amount of carbonic acid which they hold in solution, the waters of these springs are exceptionally rich in carbonates of iron and calcium; and it is to the presence of these salts and their precipitation as the carbonic acid is gradually given off, that their "petrifying" properties are due. These properties are utilized in the establishment of St. Alyre in the following manner: The water is first conducted along conduits containing shavings and twigs; upon these it deposits the greater part of its iron and other carbonates, and passes on with practically only calcium carbonate in solution. It is then made to descend, cascade-fashion, over a series of wooden shelves upon which are placed a variety of small objects which it is desired to "petrify," and which soon become hermetically sealed within an investment of calcium carbonate. The colour of this coating varies from yellowish white, on the upper shelves, to pure white on the lower, owing to the presence at first of a little residual iron, which is however completely precipitated before the water reaches the bottom of the series. Besides the encrusted nests, fruits, eggs and the like which are so commonly offered to the traveller in districts where petrifying springs occur, there are produced at St. Alyre, medallions, cameos and bas-reliefs of considerable artistic merit, which are made by allowing the water to flow over gutta-percha or sulphur moulds taken from carefully executed carvings. In the grounds around the springs, petrifactions of a variety of large animals, even of human beings, were seen, but it was generally agreed that these were more curious than beautiful. The natural bridge of travertine which spans the little stream, and which is figured in Scrope's "Volcanoes of Central France," is a feature of some geological interest, inasmuch as it is entirely composed of calcium carbonate deposited by these waters.

The mineral springs of St. Alyre belong to a group of twenty-two which rise in Clermont, or its immediate vicinity, along the course of one of the hydrothermal or eruptive faults already alluded to. The waters of all these springs are effervescent, and the carbon dioxide evolved is of such purity as to be largely used in the locality for the manufacture of Seltzer water. The salts held in solution are chiefly calcium, magnesium and sodium carbonates and sodium chloride. The amount of the last salt is so great that at certain points small marine floras have established themselves and thrive around the springs. All the waters are utilized as beverages—locally for the most part, although some are exported. Their use for baths has been but little developed, owing no doubt to the proximity of Royat, with its superior resources.

From St. Alyre the party proceeded by electric tram to Royat.

They first visited the newly instituted lapidary establishment of Royat, where they were shown, under the courteous direction of M. Demarty, all the stages in the cutting and polishing of a variety of precious and ornamental stones. Many of these, amethyst, opal, agate, jasper, fluor-spar and others, were from Auvergne localities, a fact which increased their interest for the party. Excellent specimens of these local minerals were placed at the disposal of the members, most of whom availed themselves of this kind offer, to add to their collections. After seeing the detailed processes of cutting, grinding, and polishing, by which the finished gem is gradually evolved from the mineral in its rough state, the members ascended to the show rooms. The collection of finished articles there displayed was much admired, and it was with the greatest difficulty that the ladies were prevailed upon to terminate their inspection. This at last having been effected, however, the visit concluded with a vote of thanks by the President on behalf of the members and an expression of good wishes for the continued success of the enterprise.

A few minutes' walk then brought them to the "Etablissement Thermal de Royat." Here they were most courteously and hospitably entertained by a number of gentlemen who had assembled to receive them. The President of the Board of Directors, Doctor Fredet, one of the Directors, M. Fernand Ventre, and M. Dionis du Séjour, the Director of the establishment, were formally presented, and there followed an exchange of civilities, in the course of which Dr. Fredet spoke on behalf of the hosts, and Prof. Bauerman, representing the guests, replied.

The visitors were then conducted over the great establishment, and were enabled to see the many ingenious modes in which the heated waters and the carbonic acid gas are employed in the treatment of a variety of ailments.

The most important of the springs is the famous Eugénie spring. It is to this spring in the main that Royat owes its prosperity. It rises bubbling to the surface along one of the hydrothermal faults to which the attention of the members had been called during the work of the morning. It discharges 220 gallons of water at 34° C. per minute, and 176 cubic feet of carbon dioxide, and alone furnishes 120 baths with a constant and never-failing supply. The spring of St. Mart, which is near it, is colder, having a temperature of 28° C. There are in addition four other mineral springs in Royat, and 332 in the province.

The waters of all the springs are effervescent; they are also charged with various chlorides and carbonates, and are ferruginous. Their curative effects are secured by drinking, gargling, spraying and bathing, and they are regarded as especially beneficial in arthritic affections—rheumatism and gout—in diseases of the respiratory organs, and in anemia and chlorosis. The virtues of the waters seem to have been well known and appreciated by the Romans, for in the park at Royat there are remains of extensive Gallo-Roman baths.

At the close of their most interesting tour of inspection, members, taking leave of their distinguished guides, returned 'lermont.

At dinner it was announced that the party was invited by the 'mpagnie Générale des Eaux Minerales de Royat" to be ent that evening at a gala performance to be given at the no. Thither they repaired in due course and witnessed sing representations of two little plays. Both were in verse, the gentle cadences of the performers, combined with the ious exertions of the day had a very soothing effect many of the visitors, which was rendered evident by ling heads.

EXCURSION TO GERGOVIA, AND THENCE THE PUY DE CROUEL BACK TO CLERMONT.

Director, M. J. GIRAUD.

'he *second day*, *August* 18th, was devoted mainly to the study e stratigraphy and characters of the pépérites and associated s of the Gergovia plateau. An early start was made from nont, and by combining driving and walking, an excellent ession was obtained of Gergovia and the surrounding country.)n the way the contour of the country was shewn to indicate from the period of the flowing of the lava from the cones of mont, to the Reindeer age, erosion to the extent of 66 feet epth had ensued, and during this period the alluvium of the of Sarliève had been deposited. Further along the Issoire there were seen exposures of marls with *Cypris*, associated limestones containing *Helix ramondi*, *Limnæa*, *Planorbis* mammalian remains (*Anthracotherium*, *Dremotherium*, *otherium*).

An excellent view of the whole structure of the Gergovia au was obtained at a bend in the road. At the lowest level marls and limestones of the upper beds of the Middle ocene could be distinguished, with a mass of basalt and its ourden of pépérites resting on them. Above these the escarp: assumed a gentler slope where marls with plant remains, *Melania* and *Unio* formed the surface, whilst capping all was ond mass of basalt.

n connection with Gergovia considerable discussion and rence of opinion has been ventilated in reference to the lower of basalt. Poulett Scrope, Croizet and Julien regarded it as w, and the pépérites as the result of the ejectamenta of the anoes falling into Oligocene lakes. Pomel and Michel , on the other hand, view the lower basalt as an intrusion of date and the pépérites simply as a vein phenomenon. matter has been studied by M. Giraud, and he freely all three were inspected by the members on the way to the top of this famous eminence.

Moreover the Upper Oligocene marls of Gergovia were examined, especially the beds with plant remains, worked by the Abbé Boulay. *Melania lauræ*, var., *Melanopsis hericarti*, *Unio*, *Planorbis*, &c., were observed, whilst on the top of the plateau, pebbles of Jurassic siliceous limestone were also collected. They have been derived from the Jurassic beds of the Ardèche and the Lozère, and probably represent the alluvium of rivers of Upper Miocene age.

The afternoon was devoted to the examination of some other pépéritic masses dispersed over the Limagne, in the neighbourhood north and north-east of Gergovia, and involved some pleasant and interesting drives and walks. At one of the pépéritic masses, the Puy de Crouel, prettily situated among peach orchards and vineyards, and from the top of which a delightful view was obtained, pépérites were seen passing by gradual transition into basalt. At another, known as the Puy de la Poix, a bituminous spring exudes from very compact pépérites associated with a vertical basalt dyke, the transition from pépérite to basalt being again gradual. It may be remembered that this particular class of pépérite was regarded by Scrope as the result of local volcanic eruptions through soft calcareous mud, which at the time formed the bottom of a lake.

EXCURSION FROM CLERMONT TO THE PUY DE DOME AND BACK.

Director: M. PH. GLANGEAUD.

The details of this day's proceedings will be found at the end of the following general account of the physical geography and geology of the Chain of Puys, which has been most kindly contributed by M. Glangeaud, and which includes observations which he has made and conclusions at which he has arrived during a study of the region extending over several years.

The Chain of Puys.

BY M. PH. GLANGEAUD.

PHYSICAL GEOGRAPHY.

The Chain of Puys lies a little to the N.E. of the massif of Mont Dore. As its name implies, it is a string of small volcanoes. These, which are sometimes spoken of collectively as the Dôme Mountains (Monts Dômes), are more than sixty in number, and extend with a general north and south align-

:, where it was cut by another basaltic dyke striking north- and of more recent date. The lowest basaltic mass was exposed a little further on in the ravine, where the marly :one was again baked and rendered columnar, whilst the at the upper part lost its hardness and passed imperceptibly ·épérites, so that no line of demarcation was visible between 'o formations. Moreover at this point the basaltic mass was ed, and cut the Oligocene strata very obliquely, see Fig. 41. : pépérites were compact and destitute of stratification in cinity of the basalt, whilst away from the latter they were earthy, were apparently bedded and had a very variable equently exceeding 30°. Their colour varied from grey to ı; their composition, according to M. Michel Lévy, is uniform. They consisted of an earthy, clayey cement with decomposed basaltic débris and a moderate abundance of dary calcite. They were intersected by veins of aragonite and semi-opal), whilst in the mass of pépérites there were many d masses of limestone displaced from their normal position xhibiting evidence of metamorphism both on the upper ›wer surfaces. The limestone, in fact, had been baked and orised. M. Giraud particularly pointed out that some of these ced masses of limestone appear to have been penetrated by from below, and pieces of basalt were found in cavities on ınder surface. The pépérites of Gergovia were observed to at the upper marls. The overlying limestones were tilted to 30°, were marmorised and pitted on the under surface as cases just cited.

om these facts, and as a result of his investigations amongst pépéritic masses in the Limagne, M. Giraud has come to the ing conclusions:—

ı. The pépérites always occur in association with basaltic (2). They are produced by the disintegration and ion of the Oligocene marls by the intrusion of basalt. In proximity to the basalt they are devoid of stratification, ıs at the outer surface a stratification parallel to the e of the dyke is occasionally developed, on account of the compression exerted; moreover the pressure developed has sufficient to cause the pépéritic mass to ooze out at certain , and to flow like a true volcanic stream. (4). The pépé- ınd the basaltic dykes which produced them were formed eriod between the Upper Pliocene and the commencement Middle Quaternary; they were an accompaniment of the subsidences which produced the basin of the Limagne. The itic mass of Gergovia really consists of three basaltic dykes ‹taposition with their associated pépérites; the lowest mass, ›ne regarded by some as interstratified, strikes N.E., the ıd, seen in the ravine, strikes N.W., the third, which breaks from the lowest at the cross of Gergovia, strikes N.N.E.;

to view the actual vent through which the molten matter issued.

Lava-flows.—To the east of the Chain of Puys, and running roughly parallel with it is a tract of elevated ground occupied by the crystalline rocks already mentioned, which rises at least 300 ft. above the base-level of the puys themselves. The continuity of this great bank is here and there interrupted by gaps which have been cut across it by erosion and through which have flowed westwards from the volcanic chain, streams of lava descending the steep eastern face of the crystalline massif to the Limagne below.

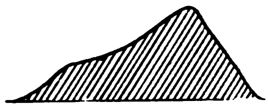


FIG. 44. PROFILE OF THE PUY DE LOUCHADIÈRE (CRATER PARTLY DEMOLISHED).

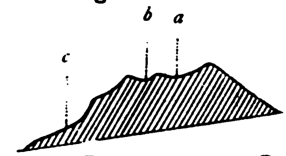


FIG. 45. PROFILE OF THE PUY DE BARME, WITH THREE CRATERS IN LINE.
a. First crater. b. Second crater. c. Third crater.

The Chain of Puys therefore is not situated upon a plateau, nor yet upon the crest of the crystalline region which separates the Limagne from the Valley of the Sioule but to the west of that crest and well below it. A consideration of these facts enables us to understand why it is that on the western side of the eruptive chain, where they met with no barrier to their advance, the lava-streams are most extensive—indeed, by their lateral coalescence they have given rise to a great sheet of lava almost continuous from end to end of the chain—while on its eastern side they are much restricted, their progress having been arrested by the great axial ridge, except where ways had already been cut through it by erosion.

On the west the individual lava-streams sometimes cover very large areas, being both broad and long. As instances may be mentioned the flows from the Puy de Côme, the Puy de Barme, and the Puy Louchadière, which are two and three miles wide, and five or more long, and descend sometimes to the Sioule itself. On the east however they are rarely broad, being usually confined to the bottom of narrow deep and often steep valleys, and forming as it were long winding tracks of molten matter, which widen out only on reaching the level plains of the Limagne. Of this type are flows from the Puy de la Nugère, the Puy de la Raviole and the Little Puy de Dôme.

Some of the lava-flows, the so-called *cheires*, constitute arid and chaotic regions, veritable rocky deserts, upon which grows but little vegetation, except lichens and mosses, and wh—

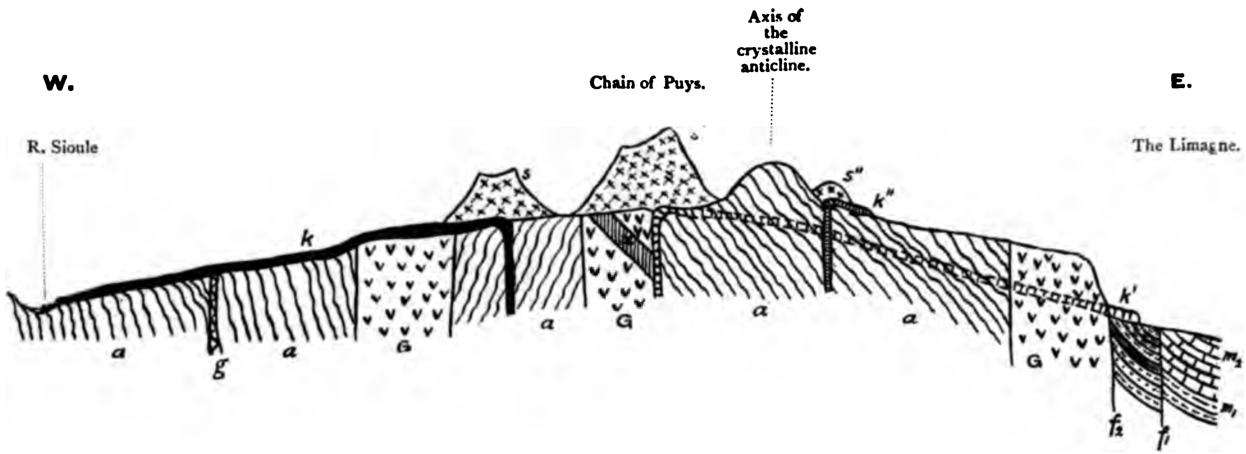


FIG. 46.—SCHEMATIC SECTION ACROSS THE CHAIN OF PUYS.

G. granite. *g.* Muscovite granite. *a.* Archæan metamorphic rocks. *x.* ancient sedimentary rocks (? Cambrian). *s, s' s."* scoria-cones. *k,k',k".* lava-flows. (The lava-flow *k'* occupies the bottom of a valley of a Pliocene age, cut in the crystalline rocks.) f_2 western boundary fault of the Limagne, f_1 hydrothermal fault. m_1 Oligocene arkoses. m_2 Oligocene limestones.

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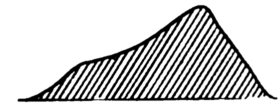
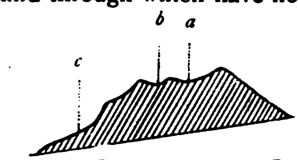


FIG. 44. PROFILE OF THE PUY DE LOUCHADIÈRE (CRATER PARTLY DEMOLISHED).



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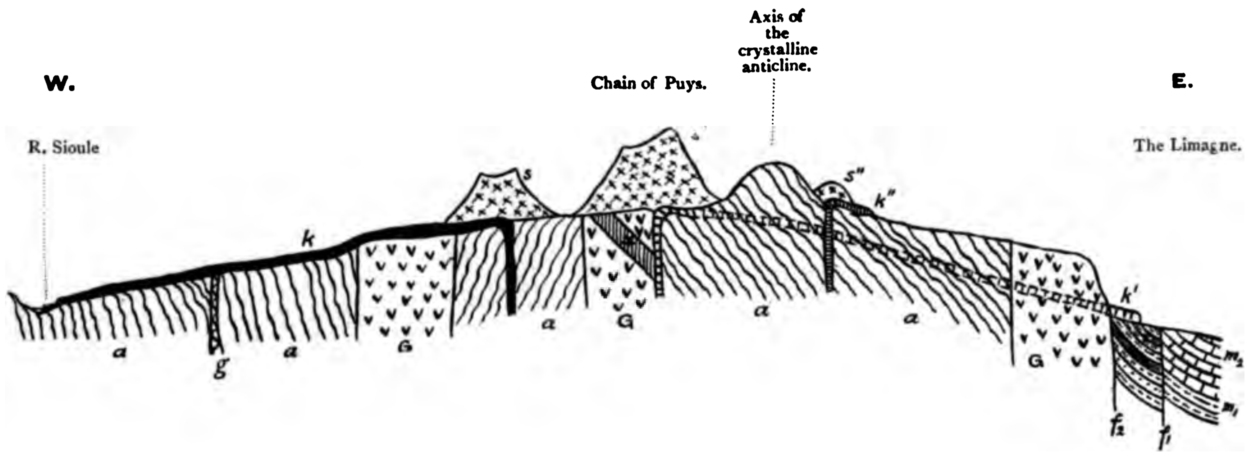

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barren and desolate aspect is in strong contrast with the more fertile tracts near at hand, where rocks of other kinds occupy the surface of the ground. Such are the cheires of Aydat, from the Puys of La Vache and Lassolas, those of Louchadière and Pariou, and especially that of Côme, which covers an area of several square miles.

Hydrology. Natural Ice-houses.—As may be inferred from what has already been said, lava-flows were frequently directed into valleys occupied by running water. It is possible to imagine however that the lava need not interfere with the drainage of the valley, but that it might serve simply as a roof or vault, beneath which the stream would still continue to flow. This is indeed what is often observed to be the case. At the end of most of the lava-flows these streams may be seen emerging as springs. The waters of such springs are remarkably fresh and clear, owing to the filtration which they have undergone in passing beneath and through the more or less porous lava. The springs of Royat issuing from the end of the lava-flow from the Little Puy de Dôme, and those of Nohannent from below the lava-stream from the Puy de Pariou are illustrative instances.

In connection with these lava-covered water-courses a singular phenomenon may sometimes be observed. At points where the lava-sheet is unusually thin, the water from below rising by capillarity through the porous rock, reaches the surface, and is subjected to evaporation. If the weather be hot, this evaporation may be so rapid as to produce a fall in the temperature of the water occupying the hollows and cavities just below the surface sufficient to cause it to be frozen. The formation of ice in this way, paradoxical as it may at first seem, only occurs during the hottest days of summer, *i.e.* when the evaporation is most rapid: it is necessarily restricted also to the thinner and more porous portions of the lava-flows. The phenomenon may be observed at several points, as for example in the neighbourhood of Pontgibaud, in the lava-flow from the Puy de Côme, and near Aydat in that from the Puy de la Vache.

GEOLOGY.

Fundamental Rocks.—The foundation, upon which the Chain of Puys reposes, consists of granites, Archæan gneisses and schists, and Cambrian sediments. This ancient complex is traversed by innumerable veins of muscovite-granite, pegmatite and microgranite. Locally also veins of mica-porphyrite, kersantite, diorite and diabase occur (Aydat, Volvic, &c.).

The region lying to the west of the puys of Pariou and

La Nugère is almost wholly formed of (? Archæan) gneiss and of mica-schists showing various degrees of metamorphism, and containing cordirite in abundance, and sometimes garnets. Isolated patches of these schists are often found enveloped in the granite.

The Cambrian rocks, which are practically unfossiliferous—up to the present time the only specimens of possible organic origin which have been found in them are certain rare impressions, believed by some to be the remains of algæ—are of considerable variety. They include quartzites, chiastolite-slates, spotted-slates, amphibole- and pyroxene-schists and green hornstones. The hornstones present a remarkable development in the neighbourhoods of Aydat, Verneuges, and Saint-Gènes-Champanelle where they are associated with diorites and diabases.

All of these fundamental rocks have been affected by folds and fractures bearing N.N.E. and N.N.W., and having therefore the general directions of the old Hercynian chain. The veins of igneous rocks have a similar orientation. Moreover the rocks are also traversed by numberless joint-planes—often rendered conspicuous by quartzose infiltrations—and these frequently extend in the same directions. These facts have a significance which will appear later.

Geological History.—Tectonics.—The works of Lecoq, of M. Julien, and especially of M. Michel Lévy, have shown that, at the end of Eocene times, the region which now forms a foundation for the Chain of Puys was very level, and formed a kind of peneplain which extended across what is now the Limagne to the Forez Hills. But at the end of the Eocene period there commenced the formation of a syncline, with a N. and S. direction—the future Limagne. On the east this was bounded by the anticline of the Forez Hills, to the west it was limited by the anticline which now forms the support for the Chain of Puys, while to the west of this again, began to appear the syncline of the Sioule. (Fig. 46.)

During the Oligocene period these folds continued to increase in amplitude. Step by step with its progressive descent the syncline of the Limagne was filled with lacustrine deposits, at first arkoses, and then more or less marly limestones. These sediments, although accumulating, according to M. Giraud, under shallow water, at least during the earlier stages, nevertheless attained a thickness of more than 3,000 ft., as has been proved by borings at various points (petroleum boring at Riom, etc.).

Miocene Eruptions.—The elevation of the Alps, as M. Michel Lévy has shewn, was not without its effects upon the massif of Central France. It further accentuated these N. and S. folds, and in doing so raised the Tertiary sediments on the flanks of the anticlines to altitudes of three thousand feet and more. But, according to M. Giraud, it was probably not until the end of Upper Miocene times that the fractures were produced, through which the great sheets of basalt—the so-called Plateaux Basalts—of Chanturgues, Gergovia, and the Hills of Clermont, rose to the surface. Besides these Plateaux Basalts, there are others, which I believe to be of the same age, occurring up on the crystalline region—*e.g.* those of Berzet, Charade, Prudelle and La Serre; and it is not unlikely that a considerable part of that region too was then deluged with great basaltic flows. Moreover similar movements and eruptions proceeded simultaneously in the Cantal, where, as demonstrated by M. Boule, a great variety of rocks of the same geological age exist.

The movements continued during the Pliocene period, and finally resulted in the production of a number of great step-faults striking parallel with the axes of the folds and having a downthrow towards the synclines. All the formations of the region, crystalline rocks, Tertiary sediments, and basaltic flows alike were affected by these dislocations. The basalts of Gergovia, Chanturgues and the Hills of Clermont are broken by them into a series of steps descending towards the middle of the Limagne, and the same is true of the basalts of Charade, La Serre, &c. The displacement of these basalts by the great N. and S. faults is one of the proofs of their great antiquity; their altered character is another.

Early Pliocene eruptions. Domitic volcanoes with craters.—At the commencement of the Pliocene period, and for a great part of it, owing no doubt to the movements described above, vulcanicity became active in the south, and it was mainly during this time that the grand volcanoes of Mont Dore and the Cantal were formed, although the first eruptions—at least in the latter case—probably occurred in Miocene times (M. Boule).

In all probability it was also during the Pliocene period that the eruptions occurred, which gave rise to the domitic volcanoes of the Chain of Puys. These are in reality dismantled volcanoes, only the bases of which remain. That they once were cratered volcanoes is proved by the alternation of lava-flows and beds of ashes which is exhibited by them. (Fig. 47.) They are found resting in some cases upon the crystalline rocks, in others upon sheets of basalt of Upper Miocene age, plentiful specimens of which rock may be found among their ejectamenta.

Erosion has often entirely removed the imperfectly consolidated portions of these volcanoes, and has left behind only the harder and more solid parts. These frequently assume the form of a dome or inverted cauldron owing to the nature of the melted domitic material, which, being very viscous, and therefore incapable of flowing freely, solidified before it had travelled far from its point of issue. The Puys of Sarcoui (Chaudron) and Clierzou are of this type. The Puy de Dôme seems to be the remains of a great domitic volcano which extended northwards across the area now occupied by the Little Puy de Dôme, as far as the Puy de Manson,—itself in great part composed of domite—and which must have attained an altitude of at least 6,000 feet. The steep rocky part of the Puy de Dôme is the neck of this great Pliocene volcano. The mass of débris at its base is at least equal to that of the mountain itself; this is also true of the other domitic puys (Sarcoui, Clierzou, Chopine) and is at once an indication of the reduction which they have suffered by erosion and a proof of their antiquity.

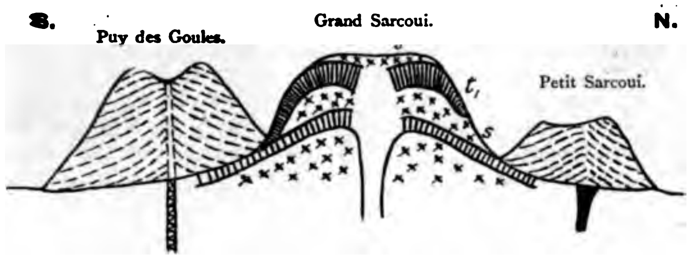


FIG. 47.—SECTION OF THE PUY DE SARCOUI (CHAUDRON) shewing the alternating sheets of stratified scoriae (s) and flows of domite (t,) of which it is made up. This Pliocene domitic puy is flanked by two Quaternary volcanoes, with well preserved craters.

Domitic ejectamenta extend northwards as far as the Puy de la Nugère, and southwards as far as the Puy de la Vache. All the more recent volcanoes occurring within these limits include domitic fragments more or less abundantly in their projections, shewing that such materials underlie them, and also demonstrating the wide extent of the domitic region which they so largely conceal from view.

The age of these domitic volcanoes is not yet fixed with any great precision. The known facts, however, some of which have been enumerated above, seem to point to the conclusion that their eruptions were contemporaneous with those of Mont Dore, and consequently that it may be regarded as Lower or Middle Pliocene.

Late Pliocene Eruptions.—The Little Chain of Puys.—On the western slope of the Valley of the Sioule there occurs a series of small volcanoes (Banson, Neuffond, La Vialle, Le

Chalusset, etc.), which, like the Chain of Puys, have a gen[illegible] but N. and S. alignment. Up to the present they have been [illegible] little studied, but they appear to have arisen under conditi[illegible] the essentially similar to those which led to the elevation of [illegible] Chain of Puys; indeed they may be regarded as a dimi[illegible] tive counterpart of that chain in relation to the Valley of [illegible] Sioule. For this reason I have suggested the name Li[illegible] Chain of Puys for this series of volcanoes.

They rest upon an alluvium, which besides contain[illegible] pebbles of the various crystalline rocks of the region a[illegible] includes examples of all the volcanic rocks of Mont Do[illegible] They are of later date therefore than that great volca[illegible] On the other hand they would seem to be of rather earli[illegible] date than the cratered volcanoes of the Chain of Puys, [illegible]

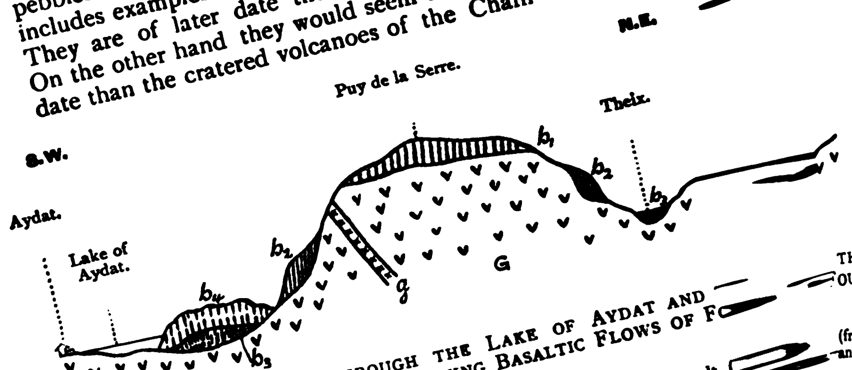


FIG. 48.—SECTION PASSING THROUGH THE LAKE OF AYDAT AND THE PUY DE LA SERRE, AND SHEWING BASALTIC FLOWS OF FOUR DIFFERENT AGES.

b_1 Miocene basalt. b_2 Upper Pliocene basalt. b_3 Lower Quaternary basalt (from the Puy de Mey). b_4 Upper Quaternary basalt (from the Puy de la Vache). G Granite. g Muscovite granite.

their state of preservation is inferior, the craters themselves being either very imperfectly preserved or entirely obli- terated. I am led to conclude, therefore, that the L[illegible] Chain of Puys is of Upper Pliocene age.

These were, however, not the only Upper Pliocene erup- tions. There are reasons for believing that the basalts coating the flanks of the little hill of La Serre and of the Puy de Berzet, and associated with obscure remains of erup- tive cones, are of the same age.

Quaternary Eruptions.—Cratered Volcanoes of the Chain of Puys.—The eruptions which gave birth to the cratered cones of the Chain of Puys took place after the close of the Pliocene period. They enveloped the domitic volcanoes, which were already considerably worn, sometimes modifying them, sometimes covering them, [illegible]nd in great part obscuring them, Their lavas, which were basic in character, ascended mainly through the reopened N.N.E. and N.N.W. fractures, which had previously given passage to the more acid Pliocene lavas—the domites. These quaternary eruptions were on a larger scale than those of the preceding period and extended farther towards the north and south.

Fractures also opened upon the partly demolished flanks of Mont Dore, and gave rise to eruptive cones grafted upon that massif, and from each of these issued lava streams of varying extent. (Servière, Guèry, Montchalm, Montcynyère, etc.)

It is now long since any eruption occurred, but from the discoveries of Pomel and Pommerol, who found two "stations" of the Reindeer age established at the end of a lava-flow from one of the most recent volcanoes (Volcan du Tartaret) and which were apparently but little posterior to the issue of the lava, it seems not improbable that man of the Chelean epoch may have witnessed some of these latest eruptions of the region.

Genesis of the Volcanoes.—Cause of the eruptions.— I have shewn that the volcano of Gravenoire is situated upon a fault, the great western fault of the Limagne, which caused the Tertiary beds to abut against the fundamental crystalline rocks; and that the little volcanoes of Beaumont are installed upon parallel faults by which these sediments and the Miocene basalt of Charade, have been depressed in a series of eastward-descending steps. These are not features of merely local occurrence however, but apply to the whole region under consideration, which as has already been explained, was folded in Mio-Pliocene times and broken by faults into a series of terraces, which have since been robbed of some of their distinctness by the action of erosion. The Chain of Puys is situated upon one of these terraces, at the foot and to the west of that highest of them all which overlooks the base of the volcanic series by a height averaging 300 feet, but at places exceeding 400 feet.

The elevated region seems then to constitute the axis of an anticline whose flanks slope on the one hand towards the Limagne and on the other towards the Sioule, as shewn in Fig. 46. And although evidence of the presence of the parallel faults is less abundant in the crystalline region than among the Tertiary sediments, satisfactory proof of their existence is nevertheless forthcoming. The peculiar topography of the region, the occurrence of definitely orientated igneous veins, and the emergence of mineral springs along the common boundary of two terraces (as in the Limagne, where such a boundary can be proved to be the trace of a fault-plane) are some of the facts from which their existence may be inferred. Everything points indeed to the conclusion that the region upon which the Chain of Puys is placed is part of a faulted anticline, whose formation, moreover, was connected with the earth-movements which led to the elevation of the Alps.

The Chain of Puys and the Little Chain of Puys occupy symmetrical positions with regard to the Valley of the Sioule. Each is placed at the base of the keystone of an arch; and their lava-flows converge towards the axis of the syncline which lies between them and along the bottom of which flows the Sioule. The lava-streams which flow from the Chain of Puys towards the Limagne have taken this direction simply because the axial ridge behind that chain was here and there breached by eastward-descending valleys which locally conducting the molten material down the eastern slopes of the anticline, prevented them from taking their more normal course, which was down the western slopes towards the Sioule.

Volcanoes do not occur exclusively to the west of the crystalline axis. A number of small eruptive points are situated to the east of it, the volcanoes of the neighbourhood of Chanat, but they only gave rise to small cinder cones and meagre lava-flows. The volcanoes of Bannière, near Volvic, of Gravenoire and of Beaumont, are also situated east of the anticlinal axis, but upon much lower terraces, as may be seen from Fig. 40.

The foregoing geological considerations afford an explanation of the peculiar topographical features of the region. I have already mentioned that the whole of these fundamental formations are cut up by numberless N.N.E. and N.N.W. joints, which were in all probability produced during and by the elevation of the Hercynian chain. Now the Chain of Puys as a whole has a general N. and S. alignment, which was determined by Tertiary movements—the elevation of the Alpine chain—but the component volcances amongst themselves are disposed along N.N.E. and N.N.W. lines. It is permissible therefore to conclude that they are installed upon fractures such as I have described, fractures which must have played a part at a variety of epochs. Some of them had already conducted domitic lavas to the surface in Pliocene times. They re-opened in Quaternary times and permitted the escape of basic lavas; but at the same time new ones appeared, which had not previously taken part in the eruptions. These fractures were directions of least resistance, and it was consequently through them that the molten matter made its way. Its escape must have been favoured by the sinking of the lateral elements of the great faulted anticline, like the slipping of the stones of an arch; indeed it is possible that herein lies one of the principal causes of volcanic eruptions. Bearing in mind that all the eruptions in this region, Miocene, Pliocene, and Quaternary, are associated with movements of the ground, is it not reasonable to conclude that these movements must have determined the issue of the deep-seated magma, and that, at least for the Chain of Puys, there is no necessity to call in the aid of liquid masses—which did not exist—to produce the volcanic phenomena?

Order of the eruptions.—It may be said of the Quaternary volcanoes, that their eruptions frequently commenced with the emission of basic lavas—the lower basalts. This is true of the Puy de Pariou, which gave birth to a lava-flow, which up to the present is undescribed. So it is of the Puys of Côme, Louchadière, la Nugère, &c. Afterwards more acid lavas escaped, sometimes andesites, sometimes labradorites; and finally there was a recurrence of basic lavas—the upper basalts.

The number of flows issuing from a volcano is sometimes only one, but more usually it is two or three (Puys of Côme, Pariou, la Nugère). The volcanoes of Barme and Montgy have emitted at least four, each of a slightly different character from the others, and all of a remarkable freshness.

Petrography.—For our knowledge of the chemistry and petrography of the lavas of the Chain of Puys we are mainly indebted to von Lasaulx and to M. Michel Lévy, especially to the latter.

The rocks belong to two series, the domites, and the andesites, labradorites, and basalts. The domites are trachytic rocks with silica ranging up to 62 per cent.; they are light in colour, being white or grayish, and usually contain a black mica and hornblende. The andesites, labradorites and basalts—lavas emitted by the Quaternary volcanoes—have a silica percentage varying between 58 per cent. and 50 per cent.; they are dark in colour, owing to the abundance of ferriferous minerals—magnetite, biotite, augite, hornblende, olivine, &c. In certain instances some of the crystals are sufficiently large to produce a distinctly porphyritic structure, but generally the rocks are so fine grained and compact that their component elements can only be distinguished by the aid of a microscope.

Minerals.—During their eruptions the volcanoes sometimes threw out well formed crystals as well as the more ordinary ejectamenta, and at various points it is possible to collect these from among the cinders. The Puys of la Vache, Lassolas, la Rodde, Montgy, and Combegrasse are prolific localities for crystals of augite and hornblende. I do not know any spot where isolated crystals of olivine are to be found, but olivine nodules are common in certain basalts of Miocene age, such as that of Mont Rodeix, and large crystals occur embedded in the porphyritic basalt of Charade.

The minerals of fumaroles are naturally abundant, the commonest of which is hematite, beautiful crystals of which may be collected from the fissures of several of the puys. In the lavas of the Puy de la Nugère martite occurs and with it are associated black mica and occasionally hypersthene. Finally in a number of the volcanoes the cinders are coated with hyalitic opal.

On the *third day, August 19th,* the party made their first acquaintance with the Chain of Puys. The leading feature of the day's excursion was the ascent of the Puy de Dôme, from the summit of which, the meteorological conditions being most favourable, it was possible, by looking to north and south, to see this wonderful trail of volcanoes from end to end, and thus to obtain an excellent idea of the chain as a whole, and of some of the facts of form and arrangement presented by the individual cones of which it is composed.

Departing from Clermont at an altitude of 1,300 feet, the party drove to Royat. Thence following an ancient Pliocene valley cut in the crystalline rocks and carpeted from near Clermont to the foot of the Puy de Dôme by a basalt flow from the Little Puy de Dôme, they gradually ascended the great escarpment, and at an altitude of 2,600 feet emerged upon the surface of the crystalline foundation which supports the Chain of Puys. Driving then across these rolling uplands to the foot of the Puy de Dôme and climbing to its summit, they finally reached an altitude of close upon 5,000 ft. (4,808).

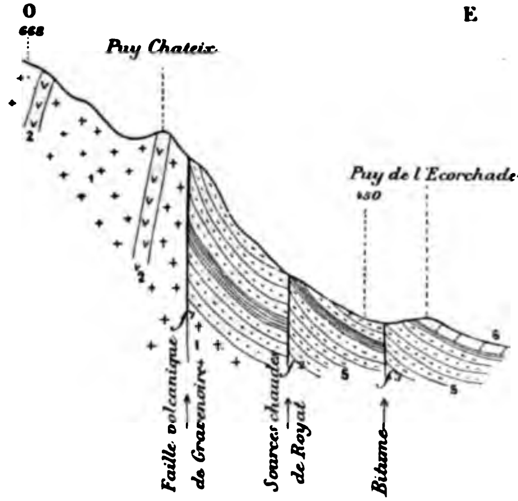
Geological observations commenced at the viaduct at Royat. At this point there is an exposure showing Oligocene beds forming part of a series let down successively towards the centre of the Limagne by a number of step-faults (see fig. 49). The beds which abut against the granite at the foot of Puy Chateix are highly inclined in the neighbourhood of the fault f_1 and consist of fine sands and of variegated and more or less argillaceous arkoses, which, according to M. Giraud, are of Sannoisian (Lower Oligocene) age.

As the beds, which at the fault have an inclination of more than 45° are followed eastwards, they become continually less inclined, until the fault f_2 is encountered, when they suddenly dip once again at a high angle. This fault is the one which gives passage at Royat to the heated waters of the Eugénie spring, which the members saw on the first day.

Followed towards the viaduct the beds again become less inclined, and marly limestones belonging to a higher horizon than the arkoses (probably Stampian) make their appearance. These in turn become highly inclined at the Puy de l'Ecorchade in contact with the fault f_3. It was along this fault that the bitumen which impregnates the rocks of this little bituminous mamelon, and which has been tentatively exploited, ascended from below. Still farther eastwards towards Clermont, other faults of the same hydro-thermal character occur, and these continue successively to depress the Tertiary sediments in such a manner as to cause the newest beds of this region to occupy the centre of the plain of the Limagne.

The two sides of the valley in which the party stood are of different geological constitution. The side in which the Oligocene

FIG. 49.—SECTION OF THE NORTHERN SIDE OF THE VALLEY OF THE TIRETAINE AT ROYAT.



1. Granite; 2. Veins of Muscovite Granite (granulite); 5. Arkoses; 6. Marly Limestones.

beds just described are seen is the north side. Turning now so as to view the south side, they saw a wall of black scoriaceous rock running along the length of the valley, and bearing upon its upper surface the majority of the houses of the town of Royat. It is the basalt flow from the Little Puy de Dôme, which made its way from the uplands above, down the valley of the Tiretaine. The river has cut its bed between the lava and the arkoses, and farther down it flows between the lava and the granite. The ascending road follows this lava stream for nearly five miles, to Fontanas.

Opposite the church at Royat, there issue from the alluvium which lies beneath the basalt, and which covers the bottom of the ancient valley, the copious springs which are appropriated for the water supply of Clermont. The underground stream by which they are fed flows beneath its vault of lava from Fontanas to Royat.

Passing onwards through Royat, the party soon left the Tertiary beds behind and entered a deep and characteristically V-shaped granite valley. The porphyritic granite was seen at numerous points during the ascent, sometimes traversed by veins of muscovite granite.

Before reaching Le Pont des Soupirs these rocks were seen to be replaced for a little distance by much contorted gneiss, with dull blue cordierite and pink garnets. Nearer to the bridge the granite was again encountered, and a mass of plicated sediments (? Cambrian) was seen enclosed within it. At the bridge the lava stream was crossed; later it was recrossed, and the winding road exhibited in succession the granite cut by veins of muscovite granite, masses of cordierite gneiss, and finally numerous thin veins of mica-porphyrite. Just before Fontanas, the basalt of the flow exhibits spheroidal weathering.

At Fontanas an elevation of about 2,500 feet was reached, and the general features of the valley just ascended, a deep furrow in the crystalline escarpment, were shown with great distinctness.

A little less than a mile beyond the Font de l'Arbre, the diminutive Puy de Chuquet Genestoux was reached. This interesting little eruptive centre is the point of origin of a miniature stream of basalt which flows towards Enval. In the midst of the scoriæ and volcanic bombs of which the cone is composed, numerous enclosures of granite were seen, all more or less baked or superficially melted, and often recrystallized. The mica has been bronzed, and the orthoclase, fused and vitrified, has the appearance of sanidine. In the cracks and fissures, apatite, opal, and zeolites are to be found.

The view from the summit of this hillock enabled the members to appreciate the fact already described, that the level of the base of the Chain of Puys is considerably lower than the crest of the crystalline anticline. This latter was seen to the east, where it rises to an altitude of 3,380 feet, while the base of the volcanic chain nowhere rises much above 3,000 feet. Looking towards the Chain of Puys, they were confronted by the imposing mass of the Puy de Dôme, to the north of which were seen the elegant crescent of the cratered Puy de Pariou and the rounded dome-like Puy de Sarcoui, while to the south rose successively the Puys of Manson, Montchié, Laschamp, and others.

Quitting Chuquet Genestoux they then proceeded towards the Puy de Dôme travelling for nearly a mile upon the surface of two superposed flows of labradorite issuing from the base of that great volcano; afterwards approaching still nearer and passing along the foot of a talus of domite they eventually reached the Col de Ceyssat, at which point it was necessary to leave the carriages.

The ascent of the Puy de Dôme (Pl. XIV., Fig. 1) from the Col de Ceyssat was easily made on foot in less than an hour, by following the excellent zig-zag path which leads to the summit.

During the ascent abundant exposures permitted the study of the petrological constitution of the mountain. It is mainly composed of a massive dyke of the light coloured and porous variety of trachyte to which the name domite has been applied. This dyke-like mass is enveloped on all sides by domitic ejectamenta, in the midst of which occur numerous blocks of basalt, granite, and ancient sedimentary rocks projected by volcanic action from below. The dyke of domite probably represents the neck of the original volcano. The mountain is now, however, no more than a ruin of its former greatness, for at the time when it first arose it must have possessed a crater rising to about 6,000 feet. Erosion has removed most of the comparatively loose and incoherent scoriæ, and has left only the hard resisting core of lava which still rises to an altitude of 4,808 feet.

The view from the summit of the Puy de Dôme, which is regarded as one of the finest in Central France is truly magnificent. Towards the north and south extends the remarkable linear series of volcanoes, many of the craters being still open and well-defined. Issuing from its base may be seen the numerous streams of lava, whose eastward and westward courses can be traced across the country by the grey and barren character of their surface, which so strongly contrasts with the fertility of the surrounding and intervening areas. Towards the east, at the foot of the escarpment of the crystalline rocks, stretches the rich plain of the Limagne, beyond which, upon the distant horizon, rise the Forez Hills continued southwards as the heights of Velay. Beyond the southern extremity of the Chain of Puys arises the great volcano of Mont Dore whose double slope is still clearly discernible. The eastern horizon is bounded by the granitic uplands of the Limousin. The members were fortunate in seeing this beautiful panorama to full advantage, thanks to a sunny day and clear atmosphere.

They also had the pleasure of inspecting the remains of the Temple of Mercury, concerning which M. Audollent, Professor in the Faculty of Letters in the University of Clermont, under whose direction excavations were being carried out, very kindly gave some interesting details. Moreover, they had the good fortune to hear an account of the famous barometric researches which the eminent French philosopher Pascal conducted upon the Puy de Dôme and in the surrounding neighbourhood in the year 1648. M. Brunhes, Professor of Physics in the Clermont University, to whom the members were indebted for this courtesy, then graciously presided at a reception in the Puy de Dôme observatory, of which he is the Director. The toast of the welfare of the Geologists' Association which M. Brunhes proposed, was cordially responded to by Mr. Whitaker, who proposed in his turn the prosperity of the University of Clermont, which was represented at the time by three of the members of its staff. At the conclusion of this pleasant little ceremony the members, much refreshed, commenced the descent of the northern slope of the mountain. On the way down they passed the Little Puy de Dôme, which is a Quaternary basaltic volcano, grafted upon the northern flank of the Puy de Dôme. Its crater is fairly well preserved, and it has given origin to that long lava flow which the party had followed during the morning's journey from Royat up the valley of the Tiretaine. To the east of this volcano, which has arisen in the midst of the domite, is another which flanks it in turn, and has likewise yielded a lava flow which up to the present time has not been described.

Passing near the foot of the Puy de Pariou, the concentric craters of which had been well seen from the summit of the Puy de Dôme, the party proceeded towards the Fontaine du Berger, which hamlet they reached after having crossed the two lava streams emitted by the Puy de Pariou; the first of these is of basalt, and has not yet been described, the other which overlies it is a voluminous flow of andesite.

After lunch at the Fontaine du Berger, a number of the more active members walked to a point whence a good view was obtained of Sarcoui (the Cauldron) with its smooth and rounded profile. Sarcoui, like the Puy de Dôme, is a Pliocene volcano with a partially dismantled crater, and formed of flows of domite alternating with beds of scoriae (Fig. 47). Erosion has removed a part of these ashes, but has been arrested by the domitic lavas which are more resisting. Quarries opened upon the flanks of the mountain reveal very clearly its internal structure. Two Quaternary volcanoes—the Puy des Goules and Little Sarcoui—flank it towards the south and north in much the same manner as the Little Puy de Dôme is attached to the Puy de Dôme.

After this little détour the carriages were once more resumed, and the return drive to Clermont was commenced. The road follows the course taken by the great andesitic flow from Pariou. At La Baraque the flow bifurcates, one half continuing towards Durtol and Nohannent, the other descending to near Chamalières in a series of veritable cascades of lava. The Cap de Prudelle, formed by a flow of Miocene basalt exhibiting a very well-marked columnar structure, and associated with a dismantled eruptive cone, separates these two lava currents. By dismounting from the vehicles and walking to the outstanding point of this promontory, the members obtained an admirable view over the city of Clermont lying below, and of the Limagne beyond.

The descent from the Cap de Prudelle to the Limagne is very id, and the drive in the cool evening along the splendidly structed winding road down the escarpment was keenly oyed. At Durtol, the western boundary fault of the Limagne ig recrossed, the low-lying fertile region of Tertiary sediments once more entered. Here a short digression was made in er to afford the members an opportunity of seeing the peculiar *yeanea* limestone in sitû; the exposure was pointed out M. Giraud, who also gave an account of the rock and its able mode of origin. It is made up almost entirely of the ılar cases of the larva of a Caddis-fly. The tubes themselves sist of agglutinated fragments of calcareous or other sand d tiny calcareous shells. The rock occurs in isolated masses he midst of felspathic sands deposited on the bed of an ent river. It is found at several stratigraphical horizons, it is best developed in the Upper Oligocene beds of the hern end of the Limagne.

Having obtained excellent specimens of this extraordinary stone, the members resumed their places in the carriages, and r a rapid drive across the level, reached Clermont about seven he evening

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KCURSION FROM CLERMONT TO MONT DORE.

Director: M. PH. GLANGEAUD.

The object of the excursion of the *fourth day, August 20th,* to study the southern extremity of the Chain of Puys and the hern flank of the massif of Mont Dore. Leaving Clermont ı after seven, the carriages followed at first the Ceyrat road, ch, running for some miles in a general southerly direction, lually approaches the crystalline escarpment up which it itually winds its way, and leads into the midst of the volcanoes ing the southern end of the Chain of Puys. At a little more ı a mile from Clermont, rising somewhat rapidly it crosses the stream from Mont Joly near Beaumont, and afterwards the from Gravenoire, both of which had been studied by the ıbers on the first day.

At the Pont de Ceyrat the crystalline escarpment is reached, g the base of which runs the fault, the eruptive fault of venoire, which has let down the Oligocene strata against the iite. Near the bridge two slightly metalliferous veins of covite-granite containing galena, pyrite and barytes are oited. Farther on, beyond Saulzet, the fault was crossed, and : it was seen that the fault-plane itself is coincident with a ı of muscovite-granite, and a very well-marked friction breccia seen exposed in the road cutting. From the muscovite-iite vein numerous fine ramifications extend into the granite, ch is itself porphyritic, and readily undergoes disintegration ı a coarse sandy product.

Ascending the escarpment from this point, the party, passing through a region of crystalline rocks pierced by innumerable veins of muscovite-granite and pegmatite, at length reached Theix, at an altitude of about 2,600 feet. Here facing them on the south was the long Miocene basaltic hill of La Serre (Fig. 48). Upon its flanks rest basalts of Pliocene age, while in the valley bottoms to north and south are two flows of basalt, one from the Puy de Mey, passing by Theix and extending as far as Fontfriede, the other from the Puy de la Vache descending to St. Amende Vallende. The hill is particularly interesting therefore, inasmuch as it exhibits basaltic horizons of four distinct ages, Upper Miocene, Upper Pliocene, Lower and Middle Quaternary, presenting four different relations to the present topography of the district.

At Fontfreide was seen a flow of labradorite, which comes from the Puy de Mey, and overlies the basaltic flow, from the same volcano, which passes by Theix. The labradorite is a handsome grey stone, and is quarried as a freestone for building and ornamental purposes.

Just beyond the Fontfreide quarries the carriages entered the tunnel of La Cassière. On emerging, the road skirting the lake of La Cassière was followed, which takes its undulating course for more than a mile across the wild and chaotic *cheire* of Aydat, formed by the confluent lava-streams from the Puys of the La Vache and Lassolas, which together have supplied the materials for this tumultuous sea of lava. It is to the damming of two valleys by these outpourings that the formation of the picturesque lakes of La Cassière and Aydat is due.

On arriving at the lake of Aydat a halt was made for lunch, which was taken in the open air, under the grateful shade of trees, and within a few feet of the water's edge.

The environs of the lake are mainly composed of granite, which is pierced by numerous veins of diorite, diabase, porphyrite, and muscovite-granite, and contains, besides, many enclosures of ancient sedimentary rocks (Cambrian?), which it has caught up within itself. M. Michel Lèvy has shewn that the granite has undergone a variety of endomorphic changes, depending upon the lithological characters of these inclusions, being converted into hornblende-granite, diorite, or even diabase. Pyroxene and amphibole-schists and eclogites have resulted from the metamorphism of masses of limestone by the granite. Several of these facts were practically demonstrated to the members by the Director.

On the western side of the lake there is an isolated patch of breccia with blocks, often of great size, representing all the rocks of Mont Dore, trachytes, trachy-andesites, hornblende-andesites, andesites with haüyne, phonolites, basalts, &c. This deposit is the remains of a formation which once spread over the slopes of the great volcano of Mont Dore, and which was transported in

Upper Pliocene times to a distance of more than ten miles from its place of origin, either by ice or by mud eruptions. To-day the volcanoes of the southern end of the Chain of Puys are interposed between this patch and Mont Dore, and they must therefore be of posterior date.

On resuming the carriages the party set out for Mont Dore, passing by Verneuges, and afterwards between the Puys of Charmont and Vichatel, beyond which were seen the splendid breached craters of La Vache and Lassolas.

At Randanne, and at a number of points in the vicinity of the lake of Aydat, deposits of diatomaceous earth (randannite) are found. The earth, which alternates with beds of peat, is extracted for use in the manufacture of dynamite and tripoli.

Passing through Randanne, the lava streams from the Puys of Montgy were seen, which descend cascade-fashion between the Puys of La Taupe and Montchal. Continuing towards the south, the Puys of Boursoux and Combegrasse and the Puy de l'Enfer were passed in succession, the last of which exhibits a dried up crater lake, which was formed as the result of an explosive eruption, by which at least one half of the volcano was destroyed.

After passing the Puy de l'Enfer, the southernmost member of the Chain of Puys, the invasion of a new territory, that of the massif of Mont Dore, was commenced, and as the day wore on, the grand panorama of the Chain of Puys, continually receding, became less and less distinct, while that of the heights of Mont Dore, ahead, became, every moment, more and more impressive.

From Randanne onwards there were seen, towards the west, great basaltic plateaux trenched by valleys of sufficient depth to display the underlying formations, which consist of cinerites and other volcanic ejectamenta more or less rearranged by water. These basalts, which extend towards the north for several miles, are the products of the last eruptions (Middle Pliocene) of the volcano of Mont Dore, which was then, as it were, enwrapped in a continuous mantle of basalt, a covering which has since been broken up by erosion. During the gradual ascent of the northern flank of the massif of Mont Dore, the party had opportunities of seeing these patches of basalt isolated by denudation, and the cineritic beds beneath them.

Leaving the carriages to follow the road the members subsequently made their way to the lake of Servières, which lies in a depression between the Puys of Servières and Comperet, two little basaltic volcanoes of Quaternary age, resting upon this flank of Mont Dore.

Rejoining the vehicles the ascent was continued. After a long detour, the road mounts to the foot of the trachytic Puy de l'Ouire where it attains an altitude of 4,100 feet. At this point a halt was called in order that the members might admire for the last time the incomparable panorama of the Chain of Puys, which, here seen from a distance, is presented in its entire length. Continuing once more the volcanic chain soon disappeared from view, and half a mile further on the two imposing piles of columnar phonolite, the Roche Tuilière and the Roche Sanadoire, were passed (Plate XIII.). A descent was made from the road to the flanks of the latter mass in order that specimens of the phonolite, which contains visible crystals of haüyne and sphene, might be collected. The issue of these phonolites in the form of dykes at several points in the northern part of Mont Dore preceded that of the basalts and was posterior to that of the labradorites and the hornblende, haüyne and nosean andesites, which are found on the western shores of lake Guéry. Beyond this lake, which was passed by the party a few minutes later, the road cuts through a basaltic flow coming from one of the numerous small quaternary centres of eruption. The basalt, which is markedly columnar, was soon left high on the sides of a deep valley cut into the soft cinerites upon which it rests. Near the Saut du Loup Cascade the cinerites include a bed of lignite, which some attempt has been made to work, and which, yielding a flora of Middle Pliocene age, is one of the fossiliferous strata which have served to fix the date of the Mont Dore eruptions.

The winding road rapidly descends to the mouth of the valley, beyond which a glimpse was seen of the cross-valley of the Dordogne, separating the massif of the Banne d'Ordanche to the north from that of Sancy to the South. Turning suddenly into the main valley, and travelling towards its source, the members saw before them the great volcanic cirque, upon the verdant floor of which the town of Mont Dore is picturesquely situated; and after a rapid drive down the valley-side they were soon in the heart of this famous little health resort, where very comfortable quarters had been secured for the whole party by M. Desroches at the Hotel Sarciron-Rainaldy.

An announcement was made in the evening that an invitation and offer of hospitality had been received from the "Compagnie des Eaux Minérales de la Bourboule" for the next day. This was duly acknowledged and accepted.

EXCURSION FROM MONT DORE TO LA BOURBOULE AND BACK.

Director: M. PH. GLANGEAUD.

The Massif of Mont Dore.—General Description.—The Massif of Mont Dore, which is close upon twenty miles in diameter, is a volcano or group of volcanoes of Miocene and Pliocene age, in great part dismantled, and deeply scored by

The Tuilière and Sanadoire Rocks, near Mont Dore.

valleys, which penetrating to the very core of the mass, permit the study of its structure in some detail.

Topographical and geological considerations lead to the belief that in the building of the massif there were at least two principal eruptive centres, one situated at or near the Pic de Sancy, the other at the Banne d'Ordanche. From these two centres lava streams radiate outwards in all directions, and form two more or less distinct massifs, which may be spoken of as the volcano of Sancy, and that of the Banne d'Ordanche. Both of these massifs are pierced moreover by dykes of considerable variety. These which are mainly trachytic in the Sancy volcano and phonolitic in the Banne d'Ordanche volcano, have greatly affected the regularity of structure of the two massifs, and have much increased their complexity.

The volcano of the Banne d'Ordanche offers a greater variety of rocks than that of Sancy and includes a certain number of types so far unknown in the latter massif, such as rhyolites, perlites, andesites with haüyne and nosean, certain types of basalt, curious micropegmatites, and others. The remarkable development of phonolites must also be borne in mind.

In the midst of the volcanic ejectamenta, which constitute a great part of the mass of the Sancy volcano, beds of alluvium and lignite occur, the latter yielding plant remains which are usually regarded as of Middle Pliocene age. On the other hand the formation of which the mountain of Perrier is composed, and which includes nearly all the rock-types of Mont Dore, contains a fauna of Middle Pliocene age. The massif of Mont Dore was in great part constructed therefore at the end of Middle Pliocene times.

During the Upper Pliocene epoch the massif of Mont Dore was clothed in ice, which carried away rocks torn from the high peaks, giving rise to distant moraines, such as that of the Valley of Chaudefour and those in the glaciated region between La Tour d'Auvergne and Bort.

In Quaternary times small basaltic volcanoes, occasionally emitting well-marked lava-flows, arose on the flanks of the massif, and it is interesting to bear in mind that these are of the same age as the cratered volcanoes of the Chain of Puys and were due to the same causative movements.

On the *fifth day, August 21st*, an early start was made for rive down the valley of the Dordogne to La Bourboule. The erary of the morning comprised the study of the eruptive ks of the Banne d'Ordanche, which differ in so many striking ects from those of the volcano of Sancy. Between these massifs is a great trench, the valley of the Dordogne, ch is also the site of issue of numerous hot springs, and which M. Michel Lèvy believes to have been determined in the first place by a great fault. Some little way down from Mont Dore the valley is traversed by a well-defined frontal moraine, which has been cut through by the river and also by the road. Grooved and striated blocks of a variety of rocks, chiefly trachytes and andesites, were found in abundance.

A little way below the moraine the party visited the Croizet warm spring, which is the property of the "Compagnie des Eaux de la Bourboule." The visitors were received by a number of the officials who had assembled to give them a preliminary greeting. The spring was discovered in an alluvium of trachyte and perlite pebbles. The waters, which are rich in salts, and have a temperature of 43° C., are to be conducted to La Bourboule.

The drive down the valley was continued until the Ravin de l'Usclade was reached. Here a great variety of rhyolites—red, white, grey, and black, and often exhibiting unmistakable flow-structure—were seen, and their intercalation in the form of flows in the lower cinerites of the Banne d'Ordanche was pointed out by the Director. Besides specimens of these, the members also collected excellent specimens of perlite, basalt, and micro-pegmatite. Veins of trachyte, phonolite, andesite, and basalt were also observed traversing this remarkably varied series of lavas. From this petrographical hunting-ground the party then proceeded to La Bourboule.

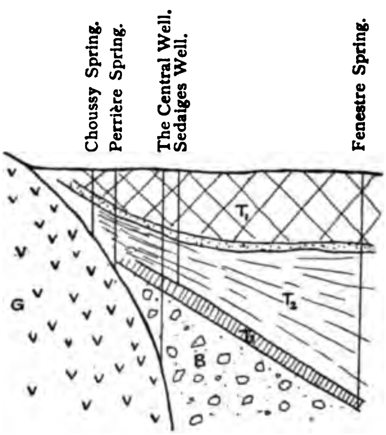


FIG. 50.—GEOLOGICAL SECTION SHEWING THE DISPOSITION OF THE HOT SPRINGS OF LA BOURBOULE, AFTER BONNEFOY.

G. Granite, B. Breccia, T1. Hard Tuff, T2. Laminated Tuff, T3. Plastic Tuff.

The waters of La Bourboule, like those of Mont Dore, were known to the Romans; but it was not until the illustrious chemist Thenard detected arsenic in them in considerable quantity that they began to acquire a reputation which is now world-wide. They rise to the surface along the boundary of a mass of granite (Fig. 50) against which abut the trachytic cinerites of the volcano of Mont Dore. This face of granite, which is clearly seen behind the "Etablissement Choussy," is probably a fault-plane. The borings by means of which the waters are collected descend either to the granite surface (Perrière spring) or penetrate into fissures in the mass of the granite (Choussy spring). Others penetrate deeply into the cinerites, but do not come into contact with the granite at all. In such cases the mineral waters which follow the course of the bands of tuff are much cooler, and have lost a good deal of their mineral constituents (Fenestre and Sedaiges springs). The arsenic in the waters probably exists in the form of sodium arseniate, which attains a proportion of twenty-eight milligrams to the litre, and is said to render the waters of especial benefit in intermittent and malarial fevers, scrofula, rickets, rheumatism, diseases of the skin, and diabetes.

Powerful pumping engines raise the waters from below, and conduct them to the bathing establishment. The party, guided by the courteous administrators, made a most interesting and exhaustive tour of inspection of the ingenious appliances with which the famous baths are equipped. Many of the members availed themselves of the offer of their guides to test for themselves the effects of the nasal and pharyngeal sprays, and found them to be most pleasant and soothing. Not content with the kindnesses with which they had already received their guests, the administrators then added the further courtesy of entertaining the party, with the utmost hospitality, at a sumptuous lunch, during which a number of cordial toasts were proposed and responded to on both sides. At its conclusion the members, bidding adieu to their hosts with many expressions of goodwill, drove back to Mont Dore, where they arrived in time to make the ascent of the Capucin before dinner.

Ascending by the funicular railway, they first inspected the elegant hall of the Capucin, and admired the view commanded from this elevated point. They then proceeded to collect specimens of the enclosures, with cordierite, hypersthene, and tridymite, which occur in the dyke of trachyte which forms the summit of the steep rocky mass. Time pressing, the return to Mont Dore was then made without delay.

In the evening at the close of dinner the party had the pleasure of a visit from M. Michel Lèvy, who was enthusiastically greeted and was formally received by the President. Subsequently M. Glangeaud presented a number of the younger geologists of the party to M. Lèvy, an honour which pleased them greatly, and which they did not fail to appreciate. The remainder of the evening was enjoyably spent at the theatre, where places had, with characteristic hospitality, been placed at the disposal of the members during their stay in the town by the "Société des Eaux du Mont Dore."

EXCURSION FROM MONT DORE TO THE PIC DE SANCY AND BACK, AND VISIT TO THE HOT SPRINGS OF MONT DORE.

Director: M. PH. GLANGEAUD.

The *sixth day*, *August 22nd*, was mainly devoted to the ascent of the Pic de Sancy, from the summit of which it is possible to obtain an excellent general view of the Mont Dore massif, and of much of the surrounding volcanic region of Central France.

The start from the town of Mont Dore was made very early in the morning. The coaches slowly ascended the beautiful valley of the Dordogne, which is strewn with abundant débris from the magnificent heights ahead and on either side. Near the point where the slope becomes too steep for the carriage-way to continue, the point where the rivers Dore and Dogne unite to form the Dordogne, an interesting example was seen of an avalanche cone, which had resulted from the melting of the winter's snows, and which in its torrential descent had felled and swept before it many of the great coniferous trees, which, here and there, clothe the valley sides, and had carried them with a great amount of mud and rocks across the road, entirely obscuring it for several hundred yards and rendering it for a time quite impassable.

The long, but by no means difficult climb to the Sancy peak, was made by the majority on foot. By many windings the path mounts to the Marsh of the Dore, which presents all the characters of a glacial cirque. It is surrounded by the crags and buttresses of the Puys of Cacadogne, Ferrand, and l'Aiguiller, which are, as it were, guarded from above and behind by the Pic de Sancy (Pl. XIV, Fig. 2). This peak, the summit of which was eventually reached, is the highest point in Central France, 6,122 feet, and is situated at the centre from which all the lava flows of the Sancy volcano diverge. It is composed of a handsome porphyritic trachyte, the phenocrysts of which are large and well defined crystals of sanidine, which occasionally weather out of the rock whole, and may be picked up from among the screes below.

The massif of Sancy is scored by profound valleys which have laid bare all of the rocks of which it is composed, exposing to view their arrangement and sequence, and thus enabling the geologist to determine the order of succession of the eruptions by which it was gradually piled up.

In Upper Pliocene times glaciers installed upon the flanks of the massif carried an abundant debris of rocks from the frost-riven peaks down into the valleys, where they still lie forming

1.—THE PUY DE DÔME, SEEN FROM LASCHAMP.

THE *PUY DE L'AIGUILLER*, SHOWING CRESTS FORMED BY VEINS OF ANDESITE.

oraines such as that which had been seen in the valley of the 'ordogne the previous day.

The view from the summit is magnificent; and the visitors ere again fortunate in the weather, which, if perhaps a little too ɔt for perfect comfort, was nevertheless very favourable for an ctensive panorama. Towards the north, beyond the valley of ıe Dordogne, the Banne d'Ordanche was seen, and it was intersting to note how suddenly the lava streams from Sancy :rminated in that direction, being met by the opposing flows om that apparently independent centre of eruption. Beyond ıd behind the Banne d'Ordanche were seen Lake Guèry and the 'uilière and Sanadoire rocks, while in the distance, and receding › the north-eastern horizon, appeared once more the linear Chain f Puys. To the east spread the green carpet of the Limagne, ordered on its further margin by the Forez Hills. To the south ıe grand volcano of the Cantal raised its blue and hazy mass in rofile against the distant sky-line.

The various features of this most extensive of the many eautiful panoramas seen during the Auvergne excursion were ointed out by the Director, and their geological significance was xplained; many facts of interest were also contributed by 1. Giraud and others who accompanied the party.

Descending a little way from the summit the members then artook of an excellent luncheon, which, with no little trouble, ad been conveyed from Mont Dore under the superintendence f M. Desroches, whose successful management of all matters elating to the commissariat contributed so greatly to the comfort nd enjoyment of the party.

After lunch a walk was taken along the ridge of the Puy 'errand to its extreme point, whence an excellent view was btained of the little Quaternary volcanoes scattered over the outhern slopes of Mont Dore, and down into the steep-sided alley of Chaudefour, barred, at its lower end, by the volcano of 'artaret, at the foot of which spreads the sheet of Lake Chambon. After as long a stay as could be allowed at this point, the eturn journey was made to Mont Dore. The majority descendıg to the carriages, returned by the road, but a few, following the rest of the Puy Cacadogne and the Roc de Cuzeau, visited the ;rande Cascade of the Dore, where they saw the section which 'as first figured and described by Poulett Scrope.

Later in the afternoon, a reception at the "Etablissement 'hermal du Mont Dore" was attended, at which M. Michel ,èvy, Dr. Tardieux, and M. Carré, the Director, welcomed the uests, and accompanied them in their tour of inspection of the ot springs and of the various appliances by which these are ıtilised at Mont Dore.

There are twelve springs, which have their origin at the foot of the cliff dominating the right bank of the valley. They are associated with a dyke of phonolite. The total daily output is very great, and the temperature of the water varies between 38°C. and 47°C., except in the case of the Marguerite spring, which has a temperature of 13°C., and is employed for the manufacture of a table water. The waters are feebly calcareous, ferruginous, and arsenical, and highly siliceous. There is also an abundant disengagement of carbon dioxide, a respect in which they differ from those of La Bourboule. Although only slightly mineralized, they have a very energetic action, especially in affections of the respiratory organs; Mont Dore is pre-eminently the spa for singers and public speakers. They are also beneficial in the treatment of rheumatism. The altitude and healthy situation of the Spa no doubt play an important part in promoting the good medicinal effects of its waters. One of the characteristic features of the town, which interested and amused the members, was the early morning procession of bathers, dressed in gaily coloured flannel bathing costumes, some walking, but most being conveyed to and from the baths in sedan chairs, carried at a rapid trot by two porters. At the conclusion of their inspection of the springs and associated premises, refreshments were offered to the visitors, and this opportunity was taken for an interchange of friendly sentiments on both sides, and for an expression of thanks on the part of those who had been so pleasantly entertained.

In the evening, at dinner, special attentions were shewn to M. Glangeaud and M. Giraud, especially to the former, as he was to direct the party for the last time on the morrow. The vote of thanks to him for his kind services during the past days, which was offered by the President, was carried by the members with acclamation. M. Glangeaud replied that he considered himself fortunate if his English confrères were pleased with their journeying in the Auvergne, and if he had contributed in any way to their enjoyment. He had, however, only repaid an outstanding debt to the Geologists' Association, with which some years ago he had the pleasure of visiting Devon and Cornwall. He hoped that his confrères amongst whom he had passed five days so pleasantly, would not forget their way to the Auvergne, where they would always be received in the same hospitable manner as were their eminent compatriots Poulett Scrope, Murchison, Lyell, Sir Archibald Geikie and others, who had published such interesting works upon the geology of the district. He concluded by raising his glass in honour of the Association. A vote of thanks was also proposed by Professor Armstrong to M. Giraud, who replied in a characteristically graceful speech. A number of other speeches having been delivered the party broke up for the evening, some availing themselves of their invitation to the theatre, others amusing themselves by watching the animated groups in the Casino.

EXCURSION FROM MONT DORE TO CHAMPEIX.

Directors: MM. PH. GLANGEAUD AND J. GIRAUD.

On the *seventh day, August 23rd,* at five o'clock in the morning members were astir in preparation for their long drive of the day. The Clermont road, traversed by the party on the fourth day, was retraced for about two miles, where it was left for one crossing the north-eastern region of Mont Dore, a region formed of various ejectamenta resorted by water and pierced by numerous trachyte dykes, or covered by masses of trachytic lava.

The laborious ascent was made round the sides of the trachytic and cineritic Puy de la Tache, whence was obtained once more a fine view of Lake Guéry and the Tuilière and Sanadoire rocks. Circumventing the Puy de la Croix Moyrand, formed of a sheet of trachyte surmounted by a table of basalt, the Col de Dyanne between the two trachytic masses was reached, and a rapid descent was made towards Bressouleille.

Before reaching this village there was an excellent general view of the eastern slopes of Mont Dore, in which the Pic de Sancy, the Puys Ferrand and Cacadogne and the Roc de Cuzeau could be seen clearly separated by a deep trench from the composite mass of the Puy de l'Angle, Puy du Barbier and Puy de la Tache. It is at the foot of the deep trench and over the other side that the Grande Cascade of the Dore is situated.

At Bressouleille the granitic foundation of the volcanic rocks was reached, and in this is cut a deep and picturesque ravine leading to the village of Chambon, whence a fine view of the valley of Chaudefour was obtained. Towards the east was seen the Quaternary volcano of Tartaret, barring the valley of the Couze Chambon, and giving rise to the lake of Chambon. Just beyond the lake a stop was made to examine the high rock-wall, the Sault de la Pucelle, a mass of lava coming from an open fissure in cinerites which contain plant-remains of Middle Pliocene age. The fissure must have been in part filled with fragments derived from the underlying formations, granite, schist, trachyte, &c., or the mass may have arrived from the depths below in a brecciated form, as may be inferred from the cores of cinerite caught up in the mass and the metamorphism undergone by the cinerite at the contact with the wall of the vent. M. Giraud inclines towards the second view and regards the breccia as contemporaneous with pépérites, from which it is distinguished by being formed by the intrusion of the basalt into cinerites instead of into marls. The whole of the western side of this dyke has been removed by erosion, giving rise to a cirque strewn with enormous masses of débris.

The journey down the valley of the Couze was resumed.

Owing to faulting, Oligocene country alternates with granitic; in the former the valley is open and broad, in the latter it forms gorges and defiles, giving a picturesque variety to the drive through the district. On approaching Murols, for instance, the granitic platform of Mont Dore is left for the Oligocene sediments which crop out in a dip in the road but are covered by ejectamenta from Tartaret. These sediments are made up of slightly clayey white sands resting on granite, in conjunction with marls, highly decalcified limestones, and red sandy clays. These Oligocene beds occupy the whole of the little basin of Murols, and extend as far as Boissières on the road to St. Nectaire. Many curious little towns were passed through, but at Murols a halt was made for lunch, before which, however, a visit was paid to the fifteenth century castle standing high up on a knoll of Oligocene sediments capped by basalt.

After lunch a visit was made, by invitation, to the charming gardens of the mayor, M. Achille Boyer, and the ladies were presented with flowers; the mayor was heartily thanked for his courtesy and generosity.

The drive was then continued along the road leading to St. Nectaire. It at first traverses Oligocene beds and beyond Boissières enters the granitic valley of the Courançou, which runs in a narrow defile. Here a complex group of faults brings the Oligocene beds again to the surface and they continue in sigh[t] as far as Verrières. At St. Nectaire a number of springs issue along these faults. They contain sodium bicarbonate and are rich in sodium chloride; they also contain arsenic in appreciable amount, and being richly calcareous are utilised in the "petrifaction" of objects as at St. Alyre. A newly discovered spring, the Papon Spring, was visited and specimens of the aragonite and orpiment which it is depositing were collected. Close at hand, more ancient springs have already deposited silica which has replaced the substance of various vegetable remains and has converted them into opal; they have also deposited chalcedony, dialogite and sulphur.

The celebrated church of St. Nectaire, dating from the 11th and 12th centuries and picturesquely situated on the hill attracted the attention of some of the members, while others were inspecting the springs.

A little beyond St. Nectaire the big granite cliff of le Puy d'Eraigne terminates abruptly at a fault, then the valley of the Couze Chambon is re-entered and broadens out considerably in the Oligocene country. The bottom of the valley is covered by the basaltic flow from the Tartaret, which in fact continues as far as Neschers, about two miles beyond Champeix, and forms the bed of the river nearly all the way. This flow is of Upper Quaternary age. There are in fact beds with reindeer remains in contact with it at its termination at Neschers. At some places

Couze forms picturesque cascades, at Pont de Saillant for nple, where a good opportunity was obtained for examining bed of the river. At Verrières a fine granitic defile was :red, and this extends as far as Montaigut. The narrowing of valley has here had the effect of increasing the accumulation he flow, so that it attains a thickness of more than 130 feet. granite defile itself is an interesting example of torrential ion acting on rocks of varying hardness. The upper part he defile consists of Oligocene beds protected by a flow of ılt. These were the first exposed to erosion, and in them the es are gentle. Lower down the granite is encountered, and eroded slope becomes suddenly steep, and the valley at the e time narrow. Phenomena of this kind were observed all ıg the road from Murols to Champeix.

At Montaigut the lower portions of the Oligocene sediments :he Auvergne were examined. Sandy clays and arkoses ing in thickness, according to locality, from 30 to 100 ft., ed directly on the granite; upon these there were fine grained ıogeneous yellow limestones, recalling the Jurassic lithohic stones, and containing brackish water fossils, *Nystia*, *itina*, *Planorbis*, *Melania*. Some of the forms are similar hose in the lower Hempstead marls, but in general they bit affinities with the species described by Fontannes as ting in the valley of the Rhone. Above these lower limees, known as the *Striatella* limestones, there are detrital ıations, sandy clays, grits and arkoses, varying in thickness from to 330 ft.; above these, limestones again occur, with a new set rackish water fossils, *Potamides lamarcki*, *Cerithium elegans*. s interesting to note that these formations exist only at Mont-t-le-Blanc, although the upper parts of the limestones with *umarcki* are encountered elsewhere; but these also contain *næa*, and are associated with the *Cypris* marls, which attain nsiderable thickness, 2,000 to 2,700 ft., in the northern part he Limagne.

The road continues in Oligocene beds from Montaigut to .mpeix, but there is a hill at St. Julien, a village a little west Champeix, where the lower limestones (with *Striatella* and *itina*) and the red or grey sandy clays are overlain by a heavy osit of white pumiceous sand, derived from Mont Dore, in ch numerous wine caves have been made. The sands are ered by a glacial deposit, consisting of big blocks of trachyte, esite, phonolite, &c., from the Monts Dore which are em-.ded in a cement of pumiceous clay. Both pumiceous sands l the moraine are of Lower Quaternary age.

At the wine caves of St. Julien the members of the party e invited to taste the wine of the country. It was universally eed that both red and white wines were remarkably good.

At dusk, after the last of numerous demonstrations by M.

Giraud of the Oligocene rocks over which the carriages had bee passing, the exceedingly picturesque village of Champeix, the haltir place for the night, was sighted, and an entry into the little tow was soon afterwards made. Champeix is built in one of th granitic defiles, bounded on the east and west by faults. T recent portion of the little town occupies the bottom of the valle whilst the old part (Marchidial), with the ruins of the picturesq church, is situated high up, near the point where the granite covered by Tertiary and Quaternary sediments (Fig. 51).

M. Glangeaud took leave of the party on this evening, a most of the members assembled in the market place to see h off, and enthusiastically expressed to him their thanks for all had done, and their regret at his departure.

EXCURSION FROM CHAMPEIX TO ISSOIRE.

Director: M. J. GIRAUD.

The *eighth day, Saturday, August 24th*, was again in pa devoted to the study of the valley of the Couze and the stra graphy of the Auvergne. Early in the morning, before breakfas the energetic Director, M. Giraud, and some of the party wer seen by others from bed-room windows, scrambling up the height near Champeix, the object being to examine the sections on the north side of the valley. The sections illustrated in Fig. 51 were the first objects of study.

At the bottom of the valley, which is still covered by the lava flow from Tartaret, β^4, and in which the Couze runs, the altitude is 1,394 ft. The sides are in the granite (γ) until sand (s), continuous with those seen at St. Julien the previous day are encountered, and here, at an altitude of 1,623 ft., i the small plateau of Anciat, capped by the basalt flow (β^3, which cuts through the pumiceous sands (s), in which bones c horse *(Equus caballus)* are found, confirming the Quaternary ag of the beds: they probably date from the beginning of that perioc Remembering that the Tartaret flow was Upper Quaternary, erosio to the extent of at least 200 ft. must have taken place during the tim between the Lower Quaternary and the Middle Quaternary, and is practically obvious that the excavation of the valley was com plete at the end of the Quaternary period. On the slope opposit Anciat, and visible from the plateau, there is a long hill rising t 1,935 ft. at the east and 2,000 ft. at the west, which consists c pumiceous sands (p^0f), covered by a thickness of glacial morain ($v'g$), and this is connected with the moraine of Perrier, know to be of Upper Pliocene age. Therefore, between the Uppe Pliocene and the Lower Quaternary, the valley has been cut dow more than 330 ft. Similar facts can be observed from differe points of the eastern slope of Mont Dore, and point to the conclusion that the actual topography of the country has been modelled between the Upper Pliocene and the Upper Quaternary, the maximum extent corresponding with the period commencing towards the end of the Pliocene and ending with the Lower Quaternary. The period of maximum excavation, at the end of the Upper Pliocene, coincides with the lowering of the level of the bottom of the plain of the Allier, produced by the last

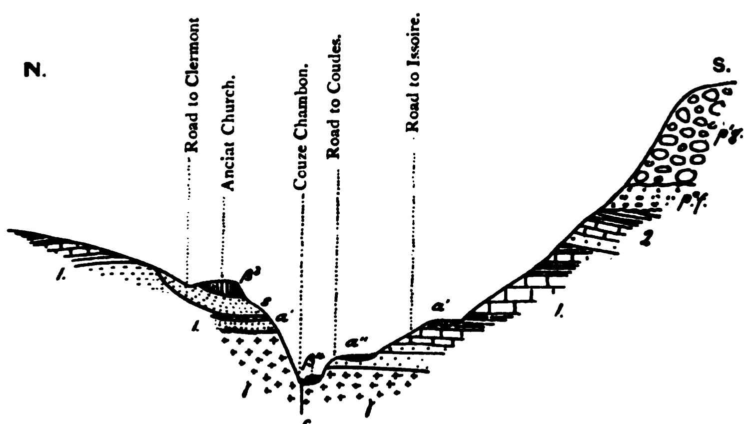


FIG. 51.—SECTION EAST OF CHAMPEIX.

γ. Granite.
1. Lower Oligocene—sandy clays, sandstones, marls and sublithographic limestones with *Nystia inchasteli*. Nyst.
2. Middle Oligocene—sandstone; marls and limestone with *Cypris* and *Cerithium* (*Potamides*) *lamarcki* Bryt.
$p^a f$. Pumiceous fluviatile beds.
$p'g$. Boulder pumiceous conglomerate (trachytic conglomerate of Perrier). Upper Pliocene.
a'. Alluvial beds. } Lower Quaternary.
s. Pumiceous sands (*Equus caballus*) } Lower Quaternary.
β^3. Basalt of Anciat. } Lower Quaternary.
a''. Alluvial beds.
β^4. Lava-flow from Tartaret. Upper Quaternary.
f. Fault.

subsidence of the Limagne. To this period, too, a greater part of the pépérites of the Limagne can be attributed, and perhaps be definitely fixed at a period comprised between the end of the time of *Elephas meridionalis* and the appearance of *Elephas antiquus*, in other words, during the early Interglacial times. Such are M. Giraud's interesting deductions.

The early morning party having returned, the drive to Issoire was commenced. The road to Clemensat, which was followed, rises at first in the granite, winds through old Champeix and reaches the red clays of the Lower Oligocene. A series of step faults is then encountered, causing the various parts of the Lower Oligocene, the red sandy clays, the calcareous grits, and the limestones with Limnæa to abut against one another along the road. Beyond Clemensat the *Striatella* limestone is again met with, and then the granite steeply cut into by the deep gorge of the river Couze Pavin once more becomes prominent. Soon after passing through the picturesque village of St. Floret, the road to Fèlines branches from the valley of the Couze down a collateral valley. The western side of this little valley is formed by a granite cliff which comes to an end at a fault from which mineral waters flow. Near the head of the valley at the side of the road the Lower Oligocene limestones with *Limnæa* are exposed. Intercalated with these limestones are beds of marls with *Cypris*, of which certain beds are full of *Cerithium plicatum*. After the examination of these rocks in a number of interesting sections, the road to Issoire was regained; this follows the Couze Pavin, runs through rich meadow land on the alluvials of that river, and about 5 furlongs before reaching Perrier passes through the tumbled mass which in the land-slip on the 24th June, 1733, fell from the Montagne de Perrier, and carried away part of the village of Pardines. Then following the road leading to Champeix, a hydraulic lime works was visited, where the upper beds of the Lower Oligocene were being quarried. The marly limestones of yellowish white colour, contain *Limnæa brongniarti*, *Potamides lamarcki*, and vertebrate remains; in the intercalated marls there are *Cypris* and abundant spicules of fresh water sponges sometimes forming continuous beds, also bands with *Cerithium plicatum* and fairly well preserved fish remains (*Prolebias stenoura*, Sauvage). Many specimens were collected in this quarry.

In the vicinity of the quarry in a ravine the sequence of beds above these Oligocene sediments could be followed; there were first ferruginous fluviatile sands with many quartz pebbles in which the Middle Pliocene *Mastodon arvernensis* is found. The sands are covered by cinerites, transported by the rivers from Mont Dore, and enclosing a Middle Pliocene flora. The trachytic breccia of Perrier lies immediately above these beds. The origin of these breccias has given rise to much dissension and discussion. Some, including MM. Julien, Michel Lévy, Munier-Chalmas, and Giraud, consider them as deposited by a great glacier coming from Mont Dore, at that time about 10,000 ft. in height, whereas M. Boule regards them as volcanic breccia coming from the Monts Dore in a muddy condition. M. Boule bases his view on the resemblance of these breccias to those of the central mass of the Cantal which are of undoubted volcanic origin. The arguments advanced in favour of the glacial character of these breccias are chiefly: the enormous size frequently attained by the blocks; the absence of any stratification or regular arrangement of the elements; the variable nature of the blocks—specimens of all the rocks of the Monts Dore are to be found in the breccia; finally there are polished and striated surfaces on many of the blocks. Moreover, the formation can be followed continuously from Perrier up to the Monts Dore, on the upper parts of the plateaux.

Again, the examination of the eastern parts of the Monts Dore discloses in many valleys remains of three successive glaciations characterised by identical deposits which are still to be seen. They are:—Firstly, the Upper Pliocene glacial deposits covering heights above the plateau basalt from Mont Dore to Perrier. Secondly, the early Quaternary glacial deposits, such as those of St. Julien and of Neschers at the horizon of the basalt of Anciat. Thirdly, the Upper Quaternary glacial deposits found in the lower parts of the valleys as at Verrières.

Luncheon was served in the garden of the inn at Perrier, and afterwards, in spite of the heat of the day, some members climbed the hill-side to examine these remarkable breccias, but very much as in the case of the pépérites, they could not decide from the one inspection either for the glacier or the volcano.

From Perrier the party drove to Issoire, following the main road, which continues on the alluvium of the Couze. This completed the work in the Department of the Puy-de-Dôme, and great were the feelings of gratitude entertained by all members of the party towards the excellent Directors who had piloted them so efficiently through the interesting neighbourhood. M. Giraud, in concluding his direction of the party, gave an interesting account of what he considered had been the geological history of the Limagne during the Oligocene period. A brief summary of his views is as follows.

A long period of erosion had reduced the Central Plateau to the condition of a peneplane before Oligocene times, but at the commencement of that period earth movements placed the Limagne in connection with the lagoons then occupying the valley of the Rhône; so that brackish water molluscs penetrated right into the heart of the central mountain area of France, and furnished the original creatures for the fossils of the *Striatella* limestones of Montaigut-le-Blanc and elsewhere. A period of repose succeeded and gave rise to the red sandy clays, then a fresh depression occurred which allowed the sea of Rhône basin to invade and cover the central region; the limestones and grit, with *Potamides lamarcki*, *Cerithium elegans*, *Limnæa*, and *Planorbis*, mark this period. Then a slight elevation cut off all the communications with the sea, and a régime of lagoons ensued; some were isolated and yielded by evaporation deposits of gypsum, salt, &c., others were in connection with supplies of fresh water, and deposited the *Cypris* marls. These lagoons were shallow, as the abundant plant remains testify; they were also subject to frequent change of position; nevertheless, they persisted for a considerable time, inasmuch as the deposits have attained considerable thickness; near Clermont, for instance, they are over 2,600 ft. thick. Fresh earth movements altered the state of things and gave rise to a new era, characterised chiefly by lacustrine and fluviatile deposits which, according to circumstances, were either the lacustrine limestones, with *Helix ramondi*, *Limnæa*, *Planorbis*, and vertebrates, or were the sands in the midst of which are encountered the isolated masses of the *Phryganea*-limestone; or else they took the form of mar with plant remains and fluviatile shells, *Unio*, *Melania*, and *Melanopsis*, as met with at Gergovia. This condition persisted, and consequently the fluviatile deposits are only found locally where they have been protected by the basaltic flows of Miocene or Pliocene times. It is noteworthy that remains of vertebrates are numerous in the Auvergne Oligocene sediment, the Middle Oligocene limestones yield *Cainotherium*, *Lophiomeryx*, *Dremotherium*, *Amphitragulus*, &c., whilst the upper beds are specially marked by *Anthracotherium* and the species of the celebrated deposit of Saint-Gérand de Puy.

Issoire was reached early in the afternoon and the excursionists were accorded a pleasant welcome by the inhabitants, whilst M. Bielawski, who had accompanied the party for several days, received them at his house, shewed them his interesting collection of Neolithic implements, &c., and, moreover, presented to those assembled copies of various works he has written on his deservedly adored Auvergne and other subjects.

Subsequently a visit was paid to the cathedral, as well as to some other sights of the town. The cathedral is an enlarged *replica* of Notre-Dame du Port at Clermont, and a fine example of the Auvergne Romanesque style. In the evening a cordial farewell was accorded M. Giraud, whose invariable kindness had made a deep impression on the party.

JOURNEY FROM ISSOIRE TO AURILLAC, AND EXCURSION IN THE VICINITY OF AURILLAC

Director: M. MARCELLIN BOULE.

Early on the *ninth day*, *August 25th*, the party made t way to the station at Issoire, whence at 8 o'clock they dep for Aurillac, their first headquarters in the Cantal. The lir first follows the river Allier southwards over the southerr of the Limagne. About Brassac the Oligocene rests upo of the small coal-basins which are dotted over the grani amorphic rocks of Central France, and in which the beds often very highly inclined. Several cuttings in which these ply dipping Carboniferous beds are displayed were passed ›ugh.

Changing at Arvant the journey was continued, and the ıagne was quitted at its southern termination. From this point line begins to ascend the valley of the Allagnon, a tributary of Allier, passing through some very wild and beautiful scenery, making straight for the heart of the Cantal volcano. ascent of this valley was continued until the tunnel of Lioran was entered, when the watershed between the basin he Loire and that of the Garonne was crossed. On emerging n the tunnel, which is cut right through the neck of the great :ano, the line runs down the valley of the Cère, through :anic rocks practically all the way to Aurillac, which however ıds on the Jordanne just above its point of confluence with Cère.

Aurillac was reached early in the afternoon, and M. Marcellin ıle and other gentlemen were at the station to welcome the ty. A move was at once made to the two hotels, the St. Pierre Trois Frères, where accommodation had been secured, and n afterwards a short drive was taken under the guidance of Boule to explore some of the geological features of the nediate neighbourhood.

Proceeding first to the Puy Courny, an exposure was seen of ocene basalt resting upon Oliogocene beds and overlain by ɔer Miocene fluviatile sand and gravel; subsequently the ɔes of the Puy de Vaurs were reached. Here the carriages e left in order that the various quarries and natural osures displaying the Oligocene beds of the hill-side might be nined in some detail. The base of the series is constituted ınfossiliferous red clays, followed above by green marls, both nging to the lowest or Sannoisian stage of the Oligocene. rlying these are white marls, with interbedded fine grained e marly limestone, the chalk-like appearance of which is ered very marked by the presence of numerous nodular masses lica, which in colour and general mode of arrangement are not ce the nodular flints of the Upper Chalk. In the limestones, especially in the silica concretions, various fresh-water fossils, as *Potamides*, *Limnæa*, and *Planorbis*, were seen. These , according to M. Boule, comprise the middle or Tongrian of the Oligocene. They are finally overlain by massive beds ompact limestone, forming the top of the escarpment, and aining admirably preserved specimens of *Helix*, *Limnæa*, *orbis*, *Cypris*, and other land or fresh-water genera. These M. Boule relegates to the upper or Aquitanian stage of the ocene.

From the level of these highest Oligocene strata a good general view was obtained of the plain of Quaternary alluvium lying below, through which the lower Cère sluggishly takes its way. The rounded U-like shape of this glaciated valley, in contradistinction to the V-like cross-section of non-glaciated valleys of this region, was pointed out by the Director.

The descent to the base of the escarpment, where the carriages were waiting, was then made, and the return drive along the flat was commenced. About half-way back to Aurillac a short halt was made at Arpajon to enter and examine the great pits there opened in the pebbly Quaternary alluvium. Shortly afterwards the return to Aurillac concluded the geological programme of the day.

EXCURSION FROM AURILLAC TO VIC-SUR-CÈRE AND BACK.

Director: M. MARCELLIN BOULE.

On the *tenth day, August 26th,* before six o'clock the conveyances had been drawn up on the Mall in front of the Hôtel St. Pierre, and a few minutes afterwards the party was on its way up the Cère valley. The day was threatening, and very soon rain began to fall and continued intermittently during the whole of the day. The result was that it was not possible to carry out the programme in full detail; but notwithstanding the inclemency of the weather all the more important features were seen in a fairly satisfactory manner.

Passing the gravel pits at Arpajon, which had been visited the previous day, the route soon passed through a region of Archæan rocks, mainly mica-schists. A little farther up the valley a glacial moraine was pointed out, spanning the valley, but it was a by no means well-marked feature.

Turning at this point into the valley of a river which falls into the Goul, the schistose rocks were soon succeeded by volcanics. At Cabane a big scarp-like exposure was seen of the andesitic breccia, which is such an important constituent in the massif of the Cantal, and concerning the mode of origin of which such differences of opinion exist. In places it attains a thickness of three thousand feet. By Scrope it was regarded as a torrential deposit. By M. Michel Lévy it is believed to be of glacial origin. M. Boule supports the view that it is a purely igneous rock, a lava in the middle—in this part it has a crystalline matrix—but that in its upper and lower parts transport by water has been an important element in its formation. This view is the one which seems to have secured most favour at the meeting of the International Congress in 1900.

At Carlat the andesitic breccia is thin, and is overlain by a

1.—THE BASALTIC PROMONTORY AT CARLAT, CANTAL.

2.—THE COLUMNAR PHONOLITE OF BORT (LES ORGUES DE BORT).

(Reproduced from "Some Geological Notes on Central France" by Miss M. S. Johnston, *Geol. Mag.*, Dec. iv, Vol. viii, No. 440, p. 59, Feb. 1901.)

ιin layer of Pliocene pebble gravel, upon which rests a sheet of lateau basalt. This last forms a flat-topped hill with vertical walls ll round (Pl. XV, Fig. 1). Carlat itself is picturesquely situated some ray up the steep side of a spur that projects well into the valley. 'he carriages were left below at the village, while an ascent was ıade to the foot of the cliff of basalt. The rock shews columnar tructure admirably above and below, but in the middle it is raversed only by a series of somewhat curved and roughly horiontal joint-surfaces. By walking round the base of the cliffs, the ınly point where access to the top is possible by ordinary means ras found, and a scramble up the narrow and steep cleft brought he party to the table-like top of the hill, whence a good view was ıbtained of the surrounding district, including the extensive pread of a great basaltic flow cut into a series of bosses and ırofound gorges, the effects of post-Pliocene erosion.

Returning to the village, a pilgrimage was made to the grave ıf J. B. Rames, the famous Auvergnat geologist. It is situated in he grave-yard of a quaint sixteenth century church, in the interior ıf which is an inscribed tablet recording the demolition of the ortified castle that once stood on the top of the hill.

Lunch was served at the inn. Continuing the drive up the 'alley of the Goul, a good example of platy phonolite was een near Jou-sous-Monjou, in one of the small dome-like masses rhich occur here and there at the base of the volcanic series of he Cantal. The peripheral part of the one here exposed is of 'esicular trachyte, which is seen to underlie the andesitic breccia. 'roceeding past the Château de Cropières, with its quaint outside taircase, the carriages soon re-entered the valley of the Cère, and t an elevated point on the valley-side, overlooking the watering ılace of Vic-sur-Cère, they were left, and a walk in rain and rind across heathy uplands to the right of the road led to the 'as de Mougudo, famous for its fossil plants.

Here the party was met by M. Pierre Marty, who, after M. 3oule had made a few interesting remarks concerning the broader ɩuestions of the geology of the Pass, gave an admirable descripion of the leaf-bearing beds, and of the remains that have been ıbtained from them. The following account, and the admirable rawings by which it is illustrated, have been most kindly sent by I. Marty for this report.

'he Plant-Bed of the Pass of La Mougudo (near Vic-sur-Cère), Cantal.

BY M. PIERRE MARTY.

The plant-bed of the pass of La Mougudo is situated upon the left bank of the Cère, above the watering-place of Vic. It appears half-way up the hill, in the face of a cliff, about

FOSSIL PLANTS FROM THE PASS OF LA MOUGUDO.

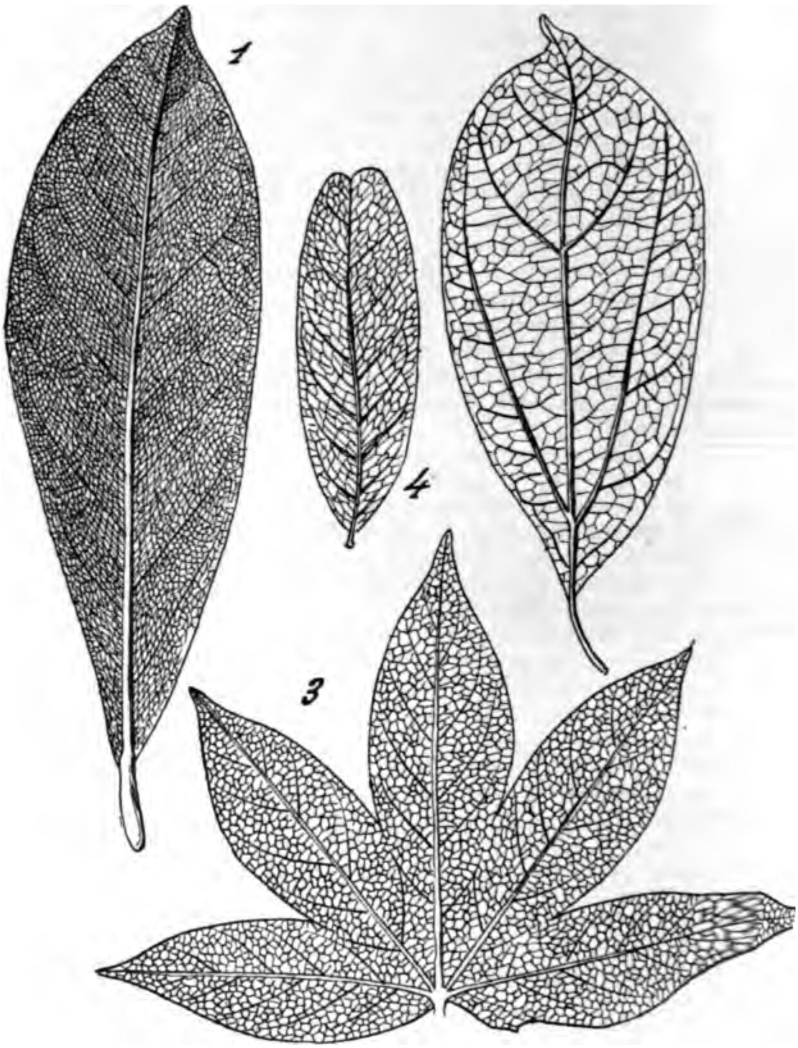


FIG. 52.—MIOCENE AND TROPICAL FORMS.

1. *Ficus lanceolata* Heer.
2. *Cinnamomum polymorphum* A. Br.
3. *Sterculia vindobonensis* Ett.
4. *Calpurnia europæa* Sap.

70 ft. high. Its height above the level of the sea is about 3,000 ft. The face of this cliff is composed of andesitic breccia, cut horizontally by two beds of cinerite, of which the lower only is fossiliferous.

The cinerites nearly always contain the remains of plants —trunks of trees, leaves, flowers and fruits—and in these the original structure and texture are often so admirably preserved as to permit of their most detailed histological study. The fossil plants of the cinerites were mentioned by Elie de Beaumont and Dufrenoy, by Poulett Scrope and others. Rames made a great collection of them, and his specimens were studied by the illustrious palæontologist de Saporta, who paid particular attention to the forms which seemed to him to suggest evolutionary deductions. His intention was ultimately to publish a systematic catalogue of the fossil-flora of the Cantal, but his death prevented the completion of this work. Saporta made known fifty-seven species; my own researches have raised the number to over one hundred, but this cannot be regarded as more than a very small part of the total number of species comprised in the complete flora. Indeed, the excavations which have been made up to the present are comparatively insignificant, in view of the number of fossiliferous bands, their extent, and their prolific character; every blow of the pick brings to light new species. A certain number of species, such as *Abies intermedia* Sap., *Bambusa lugdunensis* Sap., *Fagus pliocenica* Sap., *Carpinus orientalis* Lam., *Pterocarya fraxinifolia* Sp., and *Sassafras ferrettianum* Mass., are common in nearly all the beds. But the florules of the different beds keep none the less a very distinctive character with regard to one another. Thus, an examination of the two best known florules, that of La Mougudo with forty-five species, and that of Niac with sixty species, shows that thirteen species only are common to the two beds. Whether these differences indicate that the florules are not of the same age, or that the plants from different beds grew under very varying conditions as regards altitude, exposure, and physical and chemical assimilation, I, personally, am unable to decide. Be that as it may, however, the differences just indicated, between the various florules would suggest an interesting discussion from more than one point of view. But such a discussion cannot be entered upon here. It will suffice to say, in a general way, that the florules of the beds in closest propinquity to the crater (La Mougudo, St. Vincent) would seem to have somewhat more ancient and tropical affinities than those of the beds from the outskirts of the volcano (Niac, Lasclausades).

Let me describe briefly the characters distinctive of

FOSSIL PLANTS FROM THE PASS OF LA MOUGUDO.

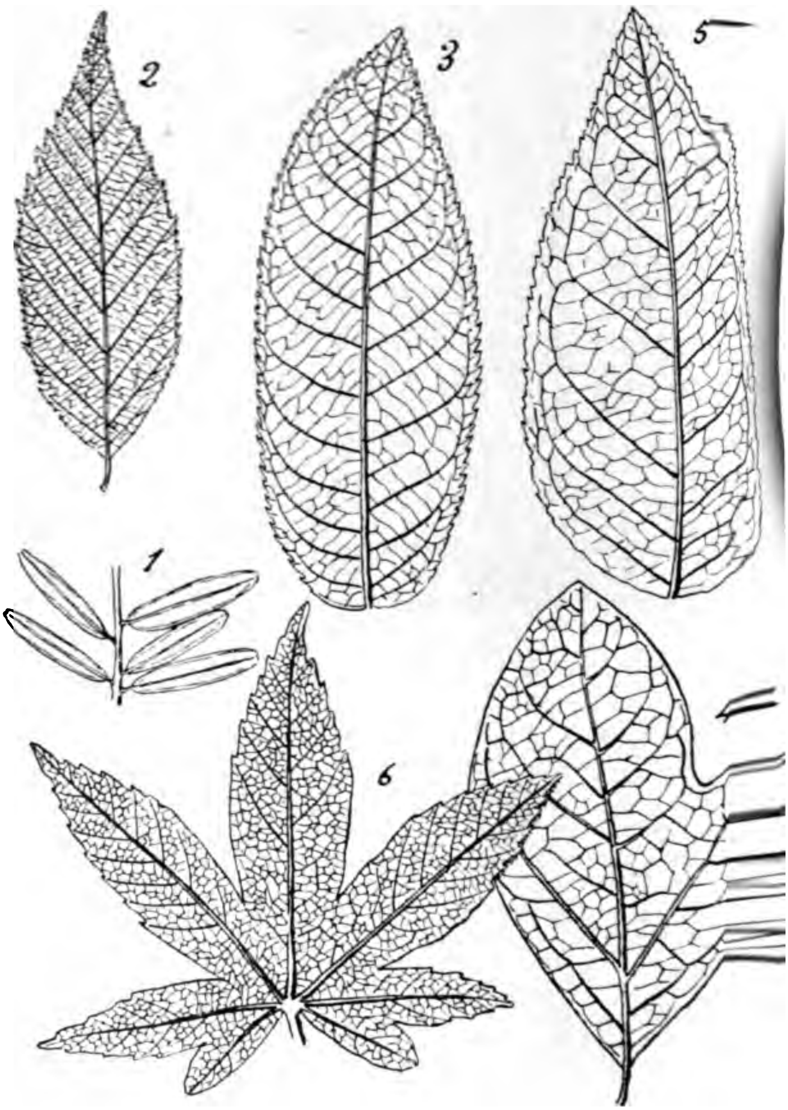


FIG. 53.—PLIOCENE AND SOUTHERN FORMS.

1. *Abies intermedia* Sap.
2. *Carpinus orientalis* Lam.
3. *Pterocarya fraxinifolia* Sp.
4. *Sassafras ferrettianum* Mass.
5. *Dictamnus major* Sap.
6. *Acer polymorphum* Sieb. et Z

the florule of La Mougudo. They will give a fair idea of those of the flora of the cinerites of the Cantal as a whole. The majority of the plant-species of La Mougudo cannot be exactly identified with their homologues of the existing flora. But the slight differences which separate them are not sufficiently important to be regarded as distinct specific characters. It was to indicate these shades of difference that de Saporta, while retaining for many of the species the specific name of their existing homologues, added the qualification var. *pliocenica*.

Taking cognisance of this observation, the florule of La Mougudo, considered from the point of view of the geographical distribution of the living homologues of the species which comprise it, falls naturally into three groups:

1. The group of species which are now tropical or subtropical.

2. The group of species which have not travelled so far towards the south.

3. The group of species which are still indigenous in the district.

The first of these groups is numerically small. It comprises scarcely any other forms than *Ficus lanceolata* H., *Cinnamomum polymorphun* A. Br., *Sterculia vindobonensis* Ett., *Grewia crenata*, Ung., and *Calpurnia europæa* Sap.; but it is very interesting, inasmuch as it stamps the whole flora with a character at once tropical and Miocene.

The second group is much more important. The principal species which characterize it are *Torreya nucifera* Sieb. et Zucc., *Abies intermedia* Sap., *Bambusa lugdunensis* Sap., *Quercus gœpperti* O. Web., *Carpinus orientalis* Lam., *Pterocarya fraxinifolia* Sp., *Zelkova crenata* Sp., *Oreodaphne heeri* Gaud., *Sassafras ferrettianum* Mass., *Dictamnus major* Sap., *Zygophyllum bronnii* Sap., *Tilia expansa* Sap., *Acer polymorphum* Sieb. et Zucc., *Viburnum tinus* L., etc. Taken as a whole, these forms are at the present time distributed along lat. 35° N., and since the Cantal lies in lat. 45° N. we may say that they have travelled ten geographical degrees towards the south since the time when the cinerites were deposited. A certain number from among them are at present confined to America, but the majority have for their habitat the great zone of mountains, often volcanic, which. from Japan to the Canary Isles, through the Himalayas and the Caucasus, stretches across Asia and Europe. The scattering of the species of La Mougudo along this zone does not imply a former connection between continents now separated by the great oceans. All naturalists know that most of the fossil-plants found in Tertiary strata of our own latitudes have been found in more ancient beds in the Arctic regions; and

FOSSIL PLANTS FROM THE PASS OF LA MOUGUDO.

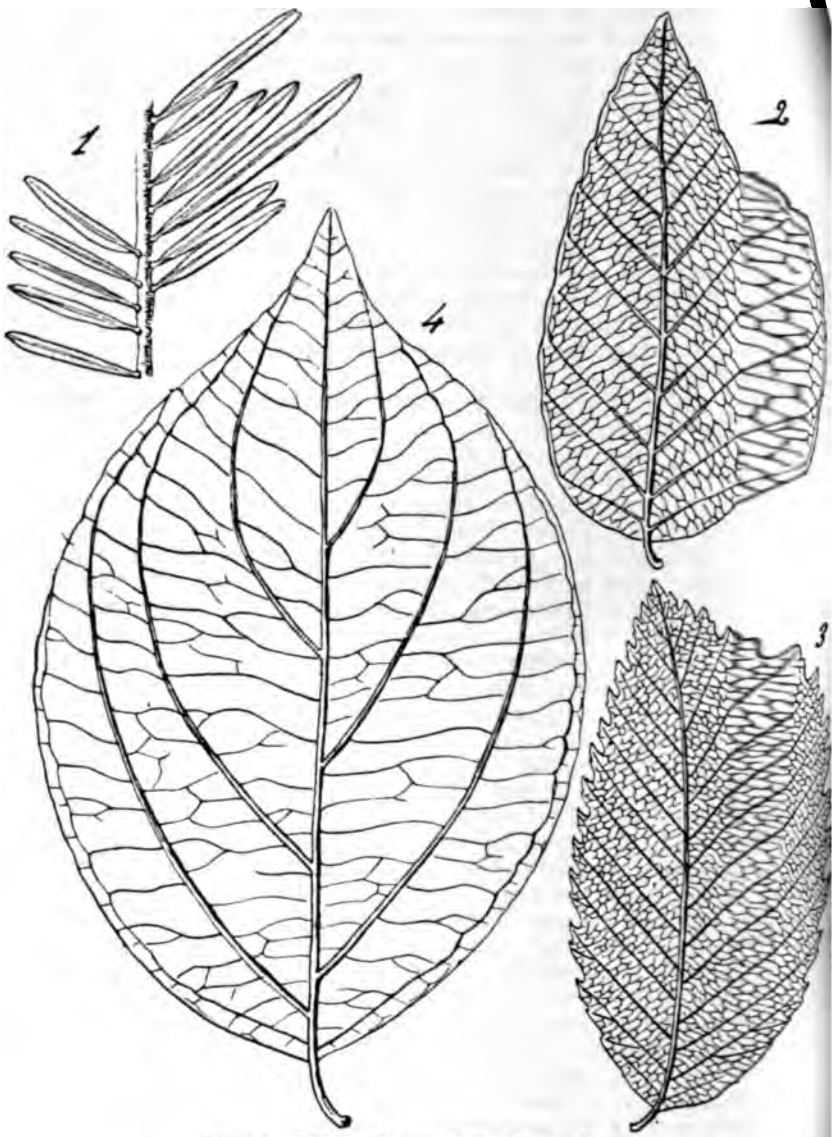


FIG. 54.—EXISTING AND INDIGENOUS FORMS.

1. *Abies pectinata* D.C.
2. *Fagus sylvatica* L.
3. *Ulmus ciliata* L.
4. *Cornus sanguinea* L.

it seems that the N. Pole must have been, during a very long period of time, a centre of vegetable creation, whence the species, driven gradually southwards by the increasing refrigeration of the climate, were forced to emigrate in a radial manner to the temperate and warm zones in which they are to be found at the present day.

The third and last group, that of the plants still indigenous in the Cantal, includes *Aspidium filix-mas* Roth., *Abies pectinata* D.C., *Carex maxima* Scop., *Fagus sylvatica* L., *Ulmus ciliata* L., *Urtica dioica* L., *Ilex aquifolium* L., and *Cornus sanguinea* L. This group, notwithstanding its feeble numerical importance, is very worthy of attention, for it shews the arrival, in the middle of the Tertiary period, of the boreal flora, which, favoured subsequently by the Pleistocene climate, succeeded eventually in usurping the soil of this district. It represents the alpine element of the great Tertiary volcano, which, according to geologists who are competent to judge, attained an altitude of close upon 10,000 ft.

The florule of La Mougudo was at first considered by de Saporta to be of Middle Pliocene age, and later it was relegated to the Lower Pliocene. The second of these estimates seems to be the more satisfactory. Indeed, in the flora obtained from the neighbouring clays of Ceyssac, with *Mastodon arvernensis*, not one of the tropical species of La Mougudo, has been recorded; and the fossil plants, from the environs of Vic, present the most striking analogies with those of the Cerdagne, from clays which together with the base of the andesitic complex of the Cantal are dated by the fauna of Pikermi.

\lt the conclusion of his remarks, M. Marty, who, before the al of the party, had had a very large number of beautiful mens laid out for inspection, informed the visitors that they free to take away as many as they liked, and added to this f generosity the further kindness of naming the specimens :ed by each member. It is scarcely necessary to say that 1arty's goodness was keenly appreciated by everyone, and hanks were freely expressed to him.

rom La Mougudo the descent was made into Vic-sur-Cère, ce train was taken back to Aurillac.

the evening, after dinner, a reception which had been ged by the "Syndicat d'Initiative du Cantal," and the muniauthorities, was held in the rooms of the "Cercle de l'Union." ugh M. le Dr. Fesq, the Mayor, could not receive the officially, yet both he himself and his colleagues identified selves with this pleasant attention to the visitors; and he, arnier, the President of the Syndicate, M. Boule, and others appropriate speeches, whilst Mr. Whitaker and Prof.

Bauerman spoke on behalf of the guests. The entertainment proved very enjoyable, and due expressions of gratitude for it were conveyed by the members to their hosts.

EXCURSION FROM AURILLAC TO MURAT.

Director: M. Marcellin Boule.

On the *eleventh day*, *August 27th*, the excursionists were again on their way betimes, and on this occasion M. Boule was accompanied by M. Ch. Puech, the engineer who superintends the maintenance of the excellent road followed during the course of the day's drive. The road, keeping an easy gradient, contours the spurs and recesses, thereby increasing the variety and charm of the delightful scenery encountered during the journey up the higher parts of the valley of the Cère. The ascent of the valley was resumed at Vic-sur-Cère, the farthest point reached on the previous day, a special train conveying the party from Aurillac to this starting point. The day was again marred by heavy, though fortunately not continuous rain, so that the district traversed was only imperfectly seen.

Very striking was the immense extension of the great flow of andesitic breccia, in which some of the blocks were of gigantic dimensions. The gorge of the Cère, however, was the first superlatively striking feature encountered, and was approached shortly after leaving Vic-sur-Cère. It is a deep, cañon-like cleft cut in the middle of a broad U-shaped valley whose floor is carpeted by Quaternary gravels. The cleft must therefore have been cut in post-Pliocene times. The river passes between high walls of the andesitic breccia and alternately collects in placid pools or is bounding over rocks in foaming falls, the varied vegetation of fresh green, the brown of the rocky, lichen-covered walls, and the subdued light filtering down from above through the apparently narrow rift, all combining to produce a remarkably impressive effect.

A little farther on beyond the Pas de la Cère, Thiézac was reached. Here the flanks of the valley are composed of andesitic breccia, overlain by andesitic and basaltic flows which form well-marked escarpments. A small outlying patch of the breccia forms a conical hill rising from the middle of the valley, upon the summit of which stands the conspicuous statue of "La Vierge de Thiézac." The breccia is underlain on one side by Archæan schists, and on the other by a dome-like mass of trachyte and phonolite, and a small patch of Oligocene sediments, partly concealed by the outlier of breccia, lies between them. The carriages were left for a few minutes while an ascent was made to the atue, from which somewhat elevated point it was possible to ake out this distribution of rock-formations, on the floor and les of the valley.

A little above Thiézac the Cère runs through a number of ines, together known as the Pas de Compaing, because of the nger of robbers which formerly existed hereabouts for the itary traveller. Here in the long road-section another example s seen of a trachyte dome underlying the andesitic breccia. e valley, both in the pass and above it, is extremely wild, a ccession of ravines, rocks, precipices, rapids, and cascades, ershadowed by the Plomb de Cantal on one side and the Puy de iou on the other, the whole hewn out of the heart of a group of lcanoes, a bewildering maze of basalts, andesites, trachytes, onolites, and other eruptive rocks.

As the road is continued upwards, it heads straight for the uthern slopes of the Puy du Lioran, which threatens to arrest s further progress, but which is pierced by the wonderful ioran tunnel. At the entrance of this, a stop was made in order take a last look down the valley of the Cère, which would not e seen again, and to hear the remarkable echoes which, as the outh of the tunnel is approached, are reflected from the glazed reens placed some little way within. The tunnel is 4,629 ft. ng, over 26 ft. wide, and about 23 ft. high, with a carriage-way nd foot-path all through; it is lighted by oil lamps, which are ept burning night and day. On emerging from the opposite end f this tunnel the members found themselves on the northern opes of the Puy du Lioran and at the head of the valley of the llagnon.

The change of scene was striking, fine and varied foliage ving given place to an almost entirely coniferous vegetation, d pleasant fertility to chill barrenness. A few yards down the lley the Hôtel du Lioran was reached, and here a good long ay was made, permitting the unusual luxury of a very leisurely ncheon, and some exploration of the hotel and its surroundings terwards. The neighbouring Puy de Griou, with its appearance inaccessibility and its association with the name of Elie de aumont, was seen not far off, but it was not possible without due delay to make its closer acquaintance.

The drive down the left bank of the Allagnon having been sumed, a fine exposure of another of the Miocene trachytic mes was seen, traversed by numerous dykes of andesite. ater, at the classic quarry of Laveissière, visited by Murchison d Lyell, Oligocene limestones and green clays were seen at the ase, covered and separated from the overlying andesitic breccia y a thin carbonaceous layer, possibly an old Miocene soil, all ierced by narrow vertical dykes of glassy basalt. From this oint all the way to Murat the road follows the scarp of a great asalt flow of Miocene age.

An early arrival at Murat enabled the members to make a pleasant exploration, under the guidance of M. Boule, of this picturesque town, with its steeply sloping streets, quaint old houses, and its church containing many curious pictures and a miracle-working statue of the Virgin, in black stone. Some of the more energetic members also made an expedition to the basaltic hill overlooking the town, in the cliffs of which a fine curved columnar structure is admirably displayed.

The "Grand Hôtel de la Gare et des Messageries" was the head quarters for dinner, but its sleeping accommodation not being sufficient for the whole party, many were quartered elsewhere in the town.

EXCURSION FROM MURAT TO THE PUY MARY, AND THENCE TO SALERS.

Director: M. Marcellin Boule.

On the morning of the *twelfth day, August 28th*, the members assembling from their various quarters, breakfasted at the hotel. The chief feature of the day's excursion, the ascent of the Puy Mary, one of the highest points in the Cantal, had long been looked forward to with pleasurable anticipations. As the fates would have it, however, the day was by far the most inclement of the whole fourteen spent in the Auvergne, and the torrent of rain that fell during the middle of the day, rendered the climb on foot from the highest point attained by the carriage-road impracticable. Nevertheless, the day was thoroughly enjoyed by most, as the naturally wild and rugged character of the mountain scenery passed through was rendered doubly impressive by the driving rain and mist, which, obscuring the details of crag and ravine, gave scope for the exercise of that fertile imagination which is generally regarded as an especial attribute of the geologist's mind.

The start was made in closed carriages, up the steep road, winding in zig-zags out of the town and past the foot of Les Orgues, a great cliff of basalt, with hundreds of prismatic columns, some straight, others bent into graceful curves. Thence the valley of the Chevade, with flanks composed of andesite breccia, basic andesites, phonolites, and basalts, was ascended. At the Col d'Entremont, the head of the valley, a series of superficial workings in a haüyne-bearing augite andesite, which was formerly quarried for roofing slates, was visited. The lava is traversed by closely-packed joints, parallel with the surface of the flow, which cause the mass to split up into thin, flat-sided slabs, and determine its suitability for roofing purposes.

'assing over the col, the valley of the Santoire was entered; his stream was followed, past the little town of Dienne, all ay up to its cirque of origin at the very foot of the summit ≥ Puy Mary. During this long and beautiful drive the study of ›gy had to be almost entirely suspended owing to the very y rain, which continued without cessation for several hours. ıtually the source of the Santoire, known in its upper part as mpradine brook, was reached, and a welcome halt was made e solitary and remote "Maison de Secours." In the limited : offered by this small habitation, the members sheltered from ·ouring rain and comforted by a brightly burning fire took lunch, which under more favourable circumstances was to have served on the summit of the Puy. The kind and able manner ıich the people of the house received and entertained such a party under such trying conditions was commended by all.

.fter lunch a long wait was made in the hope that the rain t cease; but no sign of improvement appearing a start was ıgth made through rain and mist, this time on foot, as the was both steep and heavy. In this manner the road which s round the mountain, not very far from the summit, and s roughly along the junction between the andesite of which ›eak is composed, and a sheet of porphyritic basalt which ınderneath it, was followed until its highest point, the Col lac, with an altitude of 5,190 feet was reached. Here it finally decided to abandon the ascent to the summit which ›73 feet above (5,863 feet). M. Boule gave an interesting ·iption of the geology of the immediate vicinity, but owing e adverse atmospheric conditions the features to which he red were somewhat imperfectly seen.

'he descent of the western flank of the Puy was then com-:ed, the road soon sinking by a number of zig-zags to the level ıe andesitic breccia, which was frequently seen exposed, and sionally was seen to be traversed by dykes of andesite. The r limit of the cloud of mist in which the upper part of the ntain was enshrouded was soon passed, and a better idea was obtained of the beauty of the wooded cirque forming the of the valley of the Mars, down which the party was eeding. Owing to the heavy rains which fortunately had now :d, the watercourses were fully charged, and some fine ıdes and falls were passed as the carriages, which had by this overtaken and picked up those on foot, passed rapidly ıgh the luxuriant woods, now steamy and dripping, which ıe the lower parts of the valley.

.ater, the road, ascending, passed over into the valley of the ›nne, the right bank of which it follows at a considerable ıtion, running in fact along the lower edge of the great t of vesicular and slaggy plateau basalt, which in :ene times formed a continuous mantle investing the lower

slopes of the Cantal volcano, but which has since been c
through by a system of valleys penetrating into the andesit
breccia below, and radiating from the Puy Mary outwards
all directions.

Cliffs and cuttings of this basalt skirted the right-hand sid
of the road practically all the way to Salers. To the left an
away down, could be seen the river following its sinuou
course along the valley bottom. The valley of the Maronne, lik
many others in the Cantal, shows evidence of rejuvenescence
Viewed from above the slopes on either side are seen to form
at first, part of a broad U-shaped glaciated valley, in the middl
of which, however, the river flows in a narrow V-shaped valley
evidently cut down below the level of the original floor withi
comparatively recent times, and possibly as result of a recer
movement of elevation.

The evening was well advanced when the travellers, cold wit
their long, damp drive, entered the old-world town of Saler
They were soon distributed to their various quarters, many
which were extremely quaint and old-fashioned, and to these the
mostly made an early return, after dining in two companies at th
two largest hotels of the place.

EXCURSION FROM SALERS TO BORT.

Director : M. MARCELLIN BOULE.

Salers is magnificently situated on the edge of the basal
plateau already referred to, and overlooks the confluence of t
valleys of the Upper Maronne and Aspre, and of two smal
rivers, with the main valley of the Maronne, locally known as t
valley of St. Paul de Fontanges. It commands an unrivall
view, particularly from the public grounds known as the Promena
de Barrouze. It was here on the morning of the *thirteenth da
August 29th*, that the Mayor, M. le Dr. Guillaume, kinc
arranged to receive the party and conduct them to the features
interest, of which Salers possesses a very ample share. Unc
these auspicious circumstances the party visited various fifteen
and sixteenth century houses, the ancient gates, and the chur
also of the fifteenth and sixteenth centuries, in which there
a life-size group representing the entombment. Salers w
originally fortified against the attacks of the English. T
mediæval character of the town has been retained in a co
mendable manner, and the inhabitants are justly proud of
well-preserved antiquities.

M. Boule, profiting by the assembly at the Promenade
Barrouze, there gave an account of the geology of the panoran
of the western side of the Cantal massif, which is command

from that point, and which in the clear air of the sunny morning formed a picture of rare beauty. The valleys cut in the andesitic breccia, trending upwards, narrow as they approach the Puy Mary, which is here hidden from view by the intervening Puy Violan. The flat-topped basaltic plateaux between the valleys are thus triangular in form, widening out as they descend, and having a gentle slope downwards from their point of convergence, by the continuation of which it is possible to reconstruct in the mind the profile of the great volcano before erosion had effaced so many of its original features.

After the exploration of the town the members, having thanked the Mayor for his gracious services, entered the carriages which had assembled near the church, and were soon on their way to Drugeac, whence they travelled by train through Mauriac to Bort.

The journey to Bort was picturesque, the line having the winding character of a mountain railway, taking many curves to avoid steep inclines, and commanding excellent views of the Cantal which was being left behind, of the Cezallier which, lying to the east, was being skirted, and of Mont Dore, which was being approached. The route follows the western margin of the Cantal volcanic massif for some way, passing mainly over the westward extensions of the plateau basalts which here have descended practically to the level of the surrounding region of crystalline rocks. Two or three miles beyond Mauriac, the volcanic rocks are left, and from that point to Bort the line runs over gneisses and mica-schists, except for some little distance, when it touches the southern extremity of the important coal-basin of Commentry and Decaizeville.

Arrived at Bort, which lies in the department of Corrèze, although only just over the border of the Cantal, the members were soon conveyed to their several quarters. The town is prettily situated on both banks of the Dordogne, and at the foot of a small but famous hill, known as the Orgues de Bort. Later in the afternoon this hill was ascended. Its lower slopes are of augen-gneiss, but its table-like summit is formed by a flow of phonolite, the edges of which give rise to a bold perpendicular wall, which dominates the town, and in which are displayed the large irregular polyhedral columns which have given origin to the name of the hill (Pl. XIV, Fig. 2). Between the phonolite and the augen-gneiss are beds of red clay and sand of Oligocene age.

The prospect from the flat top of the hill is one of the most extensive in Central France. It is a panorama of especial interest to the geologist, because it enables him to obtain an excellent view of the two great volcanic massifs of the Cantal and Mont Dore at one and the same time. Towards the south and south-east the horizon is bounded by the jagged profile of the weather-beaten volcano of the Cantal, while the intervening middle distance is occupied by the wooded flat-topped hills made up of its basaltic flows, with here and there a rounded knoll of trachyte, phonolite or other intrusive mass. Towards the north the similar but more elevated mass of Mont Dore, with flanks, even at this distance, seen to be scored by deep ravines, rears its peaks along the sky line. The eastern horizon between these two volcanic centres is occupied by the rolling plateau of the Cezallier, consisting of the meeting flows of basalt from either volcano. In the immediate foreground are the heath-clad hills of gneiss and schist rounded and smoothed by the glaciers which once descended from the distant heights of the Cantal. Here and there in the valleys are glacial moraines, one of which has deflected the Dordogne, which flows round the base of the hill, from its original course, damming it back and causing it to find exit over a rocky spur, through which it has gradually cut a deep ravine. The linear basin of Carboniferous rocks forms an outcrop running north and south, which may be traced across the country by the isolated wreaths of smoke marking the points where coal is being exploited. Behind, to the west, are the rolling hills of the Limousin, of granite, gneiss and schist.

The day was perfect for the view, and after M. Boule had eloquently described the panorama before them, the members remained a considerable time in order that it might impress itself upon their minds. They then made their way back to Bort, some returning in the carriages, others making the descent on foot.

The dinner, in the evening, being the last of the excursion, opportunity was taken of thanking those still present who had contributed to the success of the meeting. The people of the hotel entered into the spirit of the proceedings and provided fireworks, which produced a spectacular effect much enjoyed by the assembled youth of the town. The use of crackers to punctuate speeches, however, cannot be recommended. Votes of thanks were ably proposed by various members to M. Boule for his kindness in conducting the party through the Cantal; to M. Desroches for the careful and efficient manner in which he had carried out the important duties committed to him during the whole of the excursion; to the President, Mr. Whitaker, for the admirable and dignified manner in which he had presided over the meeting, and for the kind way in which he had, all through, given an epitome in English of the remarks of the Directors, for the benefit of those who were not able to follow the French descriptions: to Mr. Louis who had undertaken the onerous duties of Excursior Secretary; and finally to Dr. Savage, who with the greatest kind ness had acted as physician to the party, and to whom many (the members had occasion to be greatly indebted. A purse money was also presented to M. Lefort, the willing and obligi assistant of M. Desroches, in recognition of his services.

The votes of thanks were carried with an enthusiasm which only exceeded by that which greeted the replies of the pients.

Here it may be appropriately mentioned that the reception orded to the English visitors was everywhere most cordial and tifying. Not only the Directors, their friends and colleagues, also the general public, and particularly the local press, comed the party in a manner which will remain in the minds those who had the good fortune to attend the excursion, as a y pleasant recollection.

EXCURSION FROM BORT TO MONT DORE.

Director: M. Marcellin Boule.

The morning of the *fourteenth day, August 30th,* broke fine clear. Assembling before the hotel after breakfast the party, diminished by the departure for England of several of its bers, entered the two commodious brakes, and set out in the ction of Mont Dore.

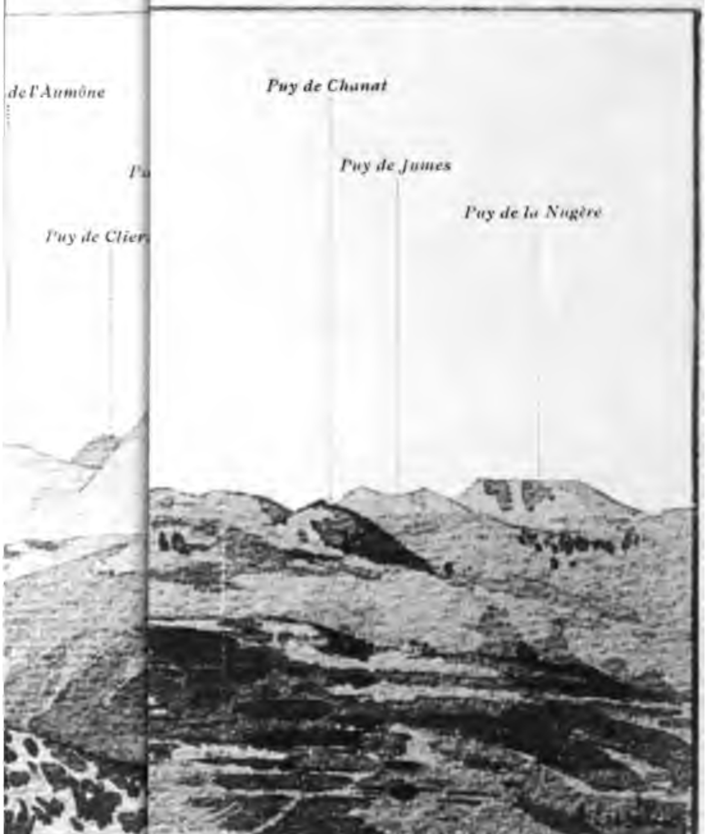
On leaving Bort the road at once ascends to the summit of ll defined but not high plain of Pliocene alluvium, consisting pebble gravel resting directly upon the old rocks below. s plain is intersected by numerous valleys in the beds of h the ancient formations of cordierite gneiss, mica schist, ite and other crystalline rocks are exposed to view. the alluvium is followed towards Mont Dore it insensibly es into morainic material, brought down by the ice which e descended from that great volcano; the pebbles are striated, large erratic blocks were seen scattered over the rounded, iated surfaces of the crystalline rocks, many being perched in arious positions upon the slopes of the roches moutonnées. direction of movement of the ice is clearly shewn by the ntation of the grooves, which are scored deep into the solid and are often as fresh as in the bed of an Alpine glacier. eover, the hill-slopes which face towards Mont Dore gentle and smooth, while those which face away are sharp, p and angular, having remained uncovered by the sheet of ice ch apparently was never of any great thickness.

These features are maintained until Latour d'Auvergne is roached, when the volcanic rocks which emanated from Mont re begin to be encountered.

At Latour d'Auvergne, an ancient Auvergnat village built upon outlying promontory of basalt, and lying rather more than f way from Bort to Mont Dore, a halt was made for lunch. ring a stroll through the village streets afterwards two or three examples were seen in the roadside of basaltic walls with ably regular columnar jointing. Reassembling at the h party remounted the carriages and with an enthusiastic g to M. Boule, who was remaining behind to carry o geological investigations in the district, resumed their jou

The drive carried the party around the western fl Mont Dore, and so completed their circuit of that mas first, rising laboriously over broad moorlands, they e began to descend through the luxuriant forest belt fon left bank of the Dordogne. Here they had the good fo encounter M. Michel Lévy, who in his specially desig veying motor car was continuing those researches whi done so much to elucidate the geology and former hi Mont Dore. After a brief interchange of courtesies M. Lévy and the President, the members saluting the French geologist, continued on their way. Their arriva railway station at Mont Dore shortly afterwards brought t clusion one of the most interesting and successful ex ever undertaken by the Geologists' Association.

"The Cha PLATE XVI.



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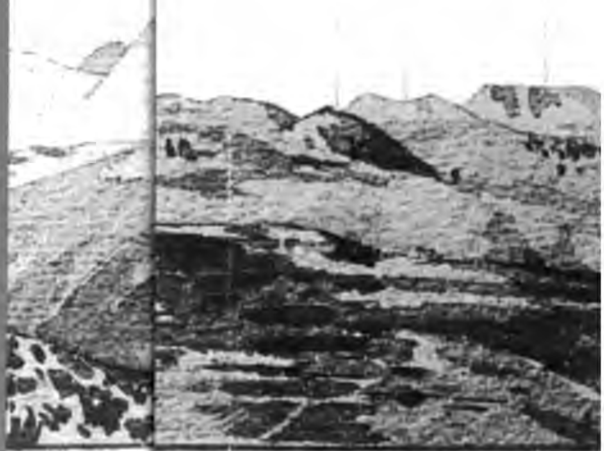


CHAIN OF

From a Water-

ORDINARY MEETING.

FRIDAY, NOVEMBER 1ST, 1901.

W. WHITAKER, B.A., F.R.S., President, in the Chair.

The following were elected Members of the Association: David Balfour, F.G.S., M.Inst.C.E., Alexander John Hogg, Thomas William Leaver, Charles Edward Pierson.

The meeting then resolved itself into a conversazione, and the following is a list of the exhibitors and their exhibits:

THE PRESIDENT, PROF. H. E. ARMSTRONG, DR. C. G. CULLIS, MISS M. S. JOHNSTON, D. A. LOUIS, P. A. B. MARTIN, DR. W. A. SAVAGE, E. W. SKEATS, A.R.C.S., B.Sc., etc., F. ROSS THOMSON, F.G.S., and MISS E. WHITLEY, B.Sc.: Rocks, micro-sections, fossils, photographs, etc., illustrating the recent excursion to Auvergne.

G. ABBOTT, M.R.C.S., F.G.S.: Specimens of Magnesian Limestone from Durham showing cellular, coralloid, and other structures.

REV. PROF. J. F. BLAKE, M.A., F.G.S.: Fossils from the Cornbrash of Boulogne.

G. FLETCHER BROWN: Fossils from the Chalk Rock near Chesham.

F. G. BROOK-FOX, F.G.S.: Bipyramidal crystals of quartz containing inclusions of anhydrite and similar crystals embedded in gypsum from Mári Hill, Salt Range, Punjab, India.

W. H. CHADWICK and PERCY EMARY, F.G.S.: Igneous and metamorphic rocks, etc., from Southern Norway.

A. K. COOMARA-SWAMY, B.Sc., F.G.S.: Charnockites and other typical rocks from Southern India.

BRYAN CORCORAN: French Burr Stone for millstones from Eure, Loire, Sarthe, etc.

A. MORLEY DAVIES, B.Sc., A.R.S.M., F.G.S.: Fossils from the Basal zones of the Gault in Kent, Surrey, Bucks, and Oxon.

HENRY FLECK, F.G.S.: Hand specimens and micro-sections of rocks from the Siebengebirge.

JAMES FRANCIS: Middle Devonian Fossils from the Eifel.

J. W. GARNHAM: A collection of Oriental carved rock crystal.

UPFIELD GREEN, F.G.S.: Continental Gedinnien and Cornish Gedinnien (?) Rocks.

W. F. GWINNELL, B.Sc., F.G.S.: A series of fossil fishes from the Lias, etc.

R. S. HERRIES, M.A., Sec.G.S.: Teeth from the Bracklesham Beds (Middle Bagshot) of Woking and Winchfield.

W. MURTON HOLMES: Sharks' teeth from the Bracklesham Beds of Woking and other localities, and fossils from the Chalk and High Terrace Gravels.

HENRY KIDNER: Corals and other fossils from the Great Oolite of Gloucestershire, and flint implements from Bushey, Herts.

D. A. LOUIS, M.I.Min.E., F.I.C., F.C.S.: Specimens and photographs from the Leicestershire "Granite" quarries.

F. P. MENNELL: Rock specimens (with micro-sections) collected during the Easter and Whitsuntide excursions, and rocks and minerals from South Australia, Western Australia, Queensland, and Tasmania.

H. W. MONCKTON, F.L.S., F.G.S.: Geological photographs.

E. T. NEWTON, F.R.S., F.G.S.: A collection of recent and fossil fish otoliths.

J. PARKINSON, F.G.S.: A series of volcanic tuffs, ashes, and other rocks from Japan.

A. E. SALTER, B.Sc., F.G.S. (on behalf of the Hon. Auberon Herbert): Specimens illustrating the remarks in the *Times* for September 3rd and 7th on "A new record of Totemism" and "Early man and his stones."

W. P. D. STEBBING, F.G.S.: The Association's Albums of Geological photographs, and specimens collected during the Easter excursion.

F. ROSS THOMSON, F.G.S.: Nummulitic Limestone from the Maritime Alps.

JOHN THRUSSELL: Specimens of the Red Chalk of Hunstanton, Japanese Arrow Heads, Jade celt from New Zealand, and a native Australian implement.

A. SMITH WOODWARD, LL.D., F.L.S., F.G.S.: Plates for forthcoming Monographs of the Palæontographical Society.

ORDINARY MEETING.

FRIDAY, DECEMBER 6TH, 1901.

W. WHITAKER, B.A., F.R.S., President, in the Chair.

The following were elected Members of the Association:—Robert S. Chandler, Miss J. R. Corcoran, A. F. Miéville, Sir Charles Cecil Stevens, K.C.S.I., Miss Mary De Fraine Whitaker.

A lecture, entitled "Notes on a Recent Visit to Egypt," was then delivered by Dr. C. W. Andrews, and was illustrated by antern slides.

ANNUAL GENERAL MEETING.

FRIDAY, FEBRUARY 7TH, 1902.

W. WHITAKER, B.A., F.R.S., President, in the Chair.

Messrs. W. J. Atkinson and M. A. C. Hinton were appointed rutineers of the ballot.

The following Report of the Council for the year 1901 was en read:

THE numerical strength of the Association on December 31st, 1901, was as follows:—

Honorary Members	16
Ordinary Members—	
a. Life Members (compounded)	157
b. Old Country Members (5s. Annual Subscription) .	5
c. Other Members (10s. Annual Subscription) . .	402
Total	580

This shows a net increase of thirteen as compared with the rresponding figures for the previous year.

During the year forty-seven new members were elected. The uncil regrets that the Association has lost six members by th: John Hopwood Blake, Arthur Bott, Arthur Cates, est Cauderlier, Rev. George Gates, and J. R. Markby.

John Hopwood Blake was born in 1843, and became a member he Association in 1877. He was educated at King's College, ndon, and was brought up as an engineer, but joined the logical Survey in 1868, and served on it until his death in 1901. had corrected the last proofs of "A Memoir on the Water ply of Berkshire from Underground Sources" some time before death, and it has been published quite lately. The Association n had the benefit of his services as a leader of excursions, n his intimate knowledge of the parts visited was freely municated.

Arthur Bott was a member of the Association from its ndation in 1858, and from the first he took an active interest ts affairs. He contributed several papers to the early numbers the PROCEEDINGS. For eleven years (from 1863 to 1874) he ed the Association as Honorary Librarian. In 1872 he was ointed one of the Trustees of the Association, an office which held until his death on June 3rd last. His position as Chief shier at the Western Branch of the Bank of England enabled to give his personal attention to the Association's account, successive treasurers have had to thank him for many rtesies shown to them.

The financial position of the Association continues satis- tory. The ordinary income in 1901 was £316 10s. 4d., or

GEOLOGISTS' ASSOCIATION.

Dr. Income and Expenditure for the Year ending Dec. 31st, 1901. Cr.

Dr.	£	s.	d.
To Balance from 1900	61	4	11
,, Life Compositions	40	10	0
,, Admission Fees	26	10	0
,, Annual Subscriptions	202	5	0
,, Dividends on Nottingham Corporation Stock	29	4	0
,, Sale of Publications	14	3	10
,, Sale of "Record"	2	15	0
,, Sale of "Paris Basin"	0	2	6
,, Advertisements	1	0	0
,, Grant from Royal Society towards the cost of publishing Dr. A. W. Rowe's papers on "The Zones of the White Chalk of the English Coast"	50	0	0
	£427	15	3

Cr.	£	s.	d.
By Printing "Proceedings"	88	4	5
,, ,, Monthly Circulars	18	3	6
,, Miscellaneous Printing	10	1	11
,, Illustrating "Proceedings" and Circulars	35	12	1
,, Postage and Carriage of Parcels	44	10	7
,, Addressing	7	4	0
,, Library (including Honorarium to Librarian of St. Martin's Library)	9	16	7
,, Attendance, Lighting, Lantern, etc., at Evening Meetings	16	13	0
,, Excursions	6	8	5
,, Insurance	2	15	0
,, Stationery	1	18	0
,, Miscellaneous Expenses	0	2	4
,, Purchase of £49 2s. 9d. Nottingham Corporation Stock, and Broker's Commission	50	0	0
,, Balance at Bank of England, Dec. 31st, 1901	136	5	5
	£427	15	3

We have compared the above account with the vouchers, and find it correct.
We have also verified the investment of £1,033 16s. 11d. Nottingham Corporation Stock.

ARTHUR W. STIFFE, } *Auditors.*
F. L. KITCHIN, }

about £25 more than in 1900; and the increase was due almost entirely to the larger amounts received under the heads of "Entrance fees" and "Subscriptions." The expenditure for the year was £241 9s. 10d., which is about £22 less than that for 1900. The decrease is due to the fact that a printers' bill for printing Proceedings, &c., amounting to £27 6s. 5d. had not been rendered when the accounts were closed and audited. The balance in hand at the end of the year was £136 5s. 5d. The large amount of this balance is chiefly due to two circumstances. In the first place the Royal Society's grant of £50 towards the publication of Dr. Rowe's Series of Papers on "The Zones of the White Chalk of the English Coast" was received in May last after the publication of Part II of Dr. Rowe's work; and secondly, Dr. Rowe has very generously made the Association a present of the £24 15s. which appeared in the last Statement of Accounts as "advanced" by him towards the publication of Part I. From the Balance in hand the Council have decided to invest a sum of £75. Of this amount £40 will represent the value of the Life Compositions received during the year, and £35 is to be looked upon as balance of the Royal Society's grant set apart towards the cost of the Parts of Dr. Rowe's work which are yet to be published.

Five numbers of the PROCEEDINGS have been issued during the past year. These, which together constitute the first half of the seventeenth volume, comprise some two hundred and seventy pages of text, and are illustrated by ten plates and thirty-eight figures.

The thanks of the Association are due to the several authors for their contributions, especially to Dr. Rowe for his second paper on "The Zones of the White Chalk of the English Coast"; to Mr. Ussher for his communication on the "Geology of the Start, Prawle and Bolt Districts of South Devon"; to Professor Bonney for his account of "The Volcanic Region of Auvergne"; and to Messrs. Kennard and B. B. Woodward for their joint paper on "The Post-Pliocene Non-Marine Mollusca of the South of England."

For illustrations the Association is indebted to the various authors who have kindly provided original drawings for the purpose, and especial thanks are due to Professor Lapworth and Mr. Sherborn for superintending the preparation of the maps and cliff-sections which illustrate Dr. Rowe's paper, and to Professor Armstrong for the admirable photographs from which the plates which so materially enhance its interest and scientific value were prepared. Moreover, for the loan of blocks and the permission for clichés, the Association is indebted to the Geological Society, the Malacological Society, and to Mr. B. B. Woodward; and, finally, to Dr. Barrois, M. Michel Lévy, M. Boule, and to Messrs. Masson & Co., Publishers, of Paris, for permitting and facilitating the reproduction in the PROCEEDINGS of several figures from the "Livret Guide" of the International Geological Congress for 1900.

The additions to the Library during the past twelve months were equal in number and interest to those of any previous year. As many completed volumes as possible have been bound and deposited at St. Martin's Library, and thus rendered available for use by members. It is satisfactory to see that the number of books issued to Members is steadily on the increase.

The following is a list of the papers read at the evening meetings:

"Twelve Years of London Geology," being the address of the President, W. WHITAKER, B.A., F.R.S.

"The Post-Pliocene Non-Marine Mollusca of the South of England," by A. S. KENNARD and B. B. WOODWARD, F.L.S., F.G.S.

"The Pleistocene Fauna of West Wittering, Sussex," by J. P. JOHNSON.

"The Volcanic Region of Auvergne," by the REV. CANON T. G. BONNEY, D.SC., LL.D., F.R.S.

Lectures were delivered by H. W. MONCKTON, V.P.G.S., on "The Geology of Swanage—Chapman's Pool to Punfield Cove (Kimeridge Clay to Upper Greensand)"; by WALCOT GIBSON, F.G.S., on "The Zonal Value of Red Strata in the Carboniferous Rocks of the Midlands"; by A. MORLEY DAVIES, B.Sc., F.G.S., on "Geology and the Growth of London"; by JOHN PARKINSON, F.G.S., on "The Geysers of the Yellowstone"; and by C. W. ANDREWS, D.Sc., F.G.S., on "A Recent Visit to Egypt."

The thanks of the Association are due to all these gentlemen.

A Conversazione was held in November, and a full list of the exhibits will be published in the PROCEEDINGS. Thanks are due to the many members who contributed to the success of that evening.

The following Museums were visited in 1901:

March 2nd.—The recently arranged Reptile Gallery of the Natural History Museum, Cromwell Road, under the direction of Dr. HENRY WOODWARD and Dr. A. SMITH WOODWARD.

March 23rd.—The Museum of the Royal College of Surgeons, under the direction of Professor CHARLES STEWART.

The following is a list of excursions made during the past year. Detailed reports will be found in parts 3, 4, and 5 of the PROCEEDINGS, vol. xvii:

DATE.	PLACE.	DIRECTORS.
April 4 to 9 (Easter)	Kingsbridge (S. Devon)	W. A. E. Ussher, F.G.S., and A. R. Hunt, M.A., F.G.S., F.L.S.
April 20	Tottenham (East London Waterworks)	W. Whitaker, B.A., F.R.S., F.G.S.
April 27	Grove Park and Chislehurst	T. V. Holmes, F.G.S.

May 4	Swanscombe	A. S. Kennard and A. E. Salter, B.Sc., F.G.S.
May 11	Leighton Buzzard, Wing, and Stewkley	A. M. Davies, B.Sc., F.G.S.
May 18	Grays Thurrock	M. A. C. Hinton and A. S. Kennard
May 25 to June 1 (Whitsuntide)	Malmesbury, Bristol, and Maiden Bradley	Rev. H. H. Winwood, M.A., F.G.S., Prof. Lloyd Morgan, F.R.S., F.G.S., Prof. S. Reynolds, M.A., F.G.S., S. S Buckman, F.G.S., J. Scanes, and B. A. Baker.
June 8	Cheam and Epsom	W. P. D. Stebbing, F.G.S.
June 15	Orpington	T. V. Holmes, F.G.S., and C. W. Osman, A.M.I.C.E.
June 22	Heathfield and Brightling	Charles Dawson, F.S.A., F.G.S.
June 29	Stanmore	W.Whitaker,B.A.,F.R.S., F.G.S., and A. E. Salter, B.Sc., F.G.S.
July 6	Twyford and The Wargrave Outlier	H. J. Osborne White, F.G.S.,andLl.Treacher, F.G.S.
July 13	Charlton	W. Whitaker, B.A., F.R.S., F.G.S., and T. V. Holmes, F.G.S.
July 20	Pulborough	J. V. Elsden, B.Sc., F.G.S.
August 17 to 31 (Long Excursion)	The Auvergne District	Prof. Marcellin Boule, Prof. P. Glangeaud, and Monsieur J. Giraud.
Sept. 21	Woking	R. S. Herries, M.A., F.G.S.

The average attendance at each excursion has been satisfactory.

Thanks are due to the Directors of the excursions, and especially to the three French geologists who so ably conducted the excursion to the Auvergne district, and so very clearly explained the wonderful phenomena of that most interesting region; also to Mr. and Mrs. Hoyle of Greenhithe, Rev. R. B. Dickson of Stewkley Vicarage, Mr. Henry Willett of Brighton, and Mr. and Mrs. Treacher of Twyford, for hospitality; and to the following for assistance: Mr. H. Stopes, Messrs. J. W. Arnold and Son, Mr. J. Hedges, Mr. G. Hay, Mr. W. H. Wickes, Mr. J. Lewis, Mr. J. Petrie, Mr. J. F. Logan-Pirie, Mr. J. Gleeson, Mr. S. J. Blackwell, Mr. Grinling, Mr. Woodgate, Mr. J. Jacomb Hood, and Mr. E. A. Ogilvie; and the many French authorities who hospitably received the members during the excursion to Auvergne.

Thanks are due to Sir Archibald Geikie, late Director General of the Geological Survey, for the presentation of the following sheets of the Geological Map of England and Wales: 349, 350, 355, and 356; and to the present Director General, Mr. J. J. H. Teall, for sheet 14 of Horizontal Sections.

The management and arrangement of the Excursions of the Association during the past year have been in the hands of the following Committee: The President, Miss Foley, J. W. Jarvis, H. W. Monckton, E. P. Ridley, A. E. Salter, W. P. D. Stebbing, Miss Whitley, A. C. Young, E. W. Skeats, and H. Bassett. The thanks of the Association are due to the members of this committee for the trouble they have taken in arranging and carrying out the Excursion programme; also to Mr. D. A. Louis, who kindly acted as Secretary for the Long Excursion to the Auvergne District. The Committee appointed to prepare an Excursion programme for 1902 was constituted as follows: The President, Miss Foley, Miss Whitley, H. Bassett, A. K. Coomara-Swamy, E. P. Ridley, A. E. Salter, E. W. Skeats, W. P. D. Stebbing, and A. C. Young.

Thanks are due to the Council of University College for the facilities they continue to offer the Association in the use of rooms for their meetings.

The changes in the House List are not numerous. Mr. W. Whitaker now retires from the Presidency. During the two years he has held that office his zeal for the well-being of the Association has been displayed alike at the Council, in the meeting-room, and in the field. The Association has prospered under his able and genial leadership, and the many enjoyable meetings and excursions over which he has presided will remain a pleasurable recollection to those who have attended them. The Association is also indebted to him for the valuable summary of "Twelve Years of London Geology," which formed the theme of his address a year ago.

Thanks are also due to Mr. H. A. Allen, Mr. Frederick Meeson, Mr. A. E. Salter, and Dr. A. Smith Woodward, who now retire from the Council.

The names of those suggested by the Council to fill the vacant offices will be found on the ballot paper.

On the motion of Mr. Upfield Green, seconded by Mr. E. Sloper, the Report was adopted as the Annual Report of the Association.

The scrutineers reported that the following were duly elected as Officers and Council for the ensuing year:

PRESIDENT:

H. W. Monckton, F.L.S., F.G.S.

VICE-PRESIDENTS:

R. S. Herries, M.A., F.G.S.
C. Davies Sherborn, F.G.S., F.Z.S.
J. J. H. Teall, M.A., F.R.S.
W. Whitaker, B.A., F.R.S.

TREASURER:
R. Holland.

SECRETARIES:

Percy Emary, F.G.S.	Miss Mary C. Foley, B.Sc.

EDITOR:
C. Gilbert Cullis, D.Sc., F.G.S.

LIBRARIAN:
Henry Fleck, F.G.S.

TWELVE OTHER MEMBERS OF COUNCIL:

L. L. Belinfante, M.Sc., B. ès L.	Bedford McNeill, A.R.S.M., F.G.S.
Rev. J. F. Blake, M.A., F.G.S.	John E. Piper, LL.B.
A. K. Coomara-Swamy, B.Sc., F.L.S., F.G.S.	W. P. D. Stebbing, F.G.S.
Upfield Green, F.G.S.	Captain A. W. Stiffe, F.G.S.
Dr. Edward Johnson.	Miss E. Whitley, B.Sc.
A. S. Kennard.	A. C. Young, F.C.S.

The best thanks of the Association were then voted to the retiring President, Members of Council, Auditors, and Scrutineers.

The President then delivered his address, entitled "A Dozen Years of London Geology (Eocene, Chalk, and Underground)."

On the motion of Mr. E. T. Newton, seconded by Mr. H. W. Burrows, it was resolved that the President's address be printed in full.

ORDINARY MEETING.

FRIDAY, JANUARY 3RD, 1902.

W. WHITAKER, B.A., F.R.S., President, in the Chair.

John C. Thrussell was elected a Member of the Association.

Capt. A. W. Stiffe and Dr. F. L. Kitchin were elected Auditors.

A lecture was then delivered by Dr. Vaughan Cornish, F.G.S., on "The Waves of Sand and Snow," illustrated by lantern slides.

ORDINARY MEETING.

FRIDAY, FEBRUARY 7TH, 1902.

H. W. MONCKTON, F.L.S., F.G.S., President, in the Chair.

James William Johnson, Alexander Oberlin Mackellar, M.D., F.R.C.S., L.S.A., and Alfred Tarver were elected Members of the Association.

There being no further business, the meeting then terminated.

A DOZEN YEARS OF LONDON GEOLOGY.

(EOCENE, CHALK AND UNDERGROUND.)

By W. WHITAKER, B.A., F.R.S.

(Presidential Address, delivered February 7th, 1902.)

1. INTRODUCTORY.

I PROPOSE to continue my subject of last year in a downward direction, but I have slightly changed its title. Then the definite number twelve was used: now the less definite and more elastic dozen takes its place. Another year has passed, and it is therefore handy to extend one's views to a period of years bounded by that particular dozen which is usually associated in our minds with the purveyors of our daily bread. Moreover, thirteen is an unlucky number, and I have a weakness for things that are reputed unlucky. My Presidential Addresses now number thirteen. I am grieved to break the charm by adding to the number to-night.

The work of the past year chiefly refers to Drift and Recent Beds, and these will be first noticed, so as to continue the record of last year, and to supplement omissions therein. It is to the Essex Field Club that we are chiefly indebted for the publication of the papers in question.

2. RECENT AND DRIFT (*continued*).

1895, 1896.

A. S. KENNARD. Pleistocene Mollusca of Crayford.*

This paper marks, I believe, the first appearance of Mr. Kennard on the geologic scene. It adds *Littorina rudis* and *Limax agrestis* to the local list. The former is a dwarfed example, and "points to the proximity of estuarine conditions."

The same author's "Unio littoralis in Pleistocene Times" † is general, but refers to Crayford.

1900 (wrongly dated 1899 on title-page).

H. STOPES. On the Discovery of *Neritina fluviatilis* with a Pleistocene Fauna and Worked Flints in High Terrace Gravels of the Thames Valley. ‡

Notices the occurrence at Swanscombe of 10 feet of shelly sand and gravel, also with bones, teeth and worked stones. "The association of *Neritina fluviatilis* with so many extinct species

*Science Gossip, n. ser., vol. ii, no. 14, pp. 39, 40.
† Science Gossip, n. ser., vol. iii, no. 29, pp. 118, 119.
‡ Journ. Anthrop. Inst., vol. xxix, pp. 302, 303.

and at this altitude in British gravels has not hitherto been recorded." A list, by Mr. Kennard, of the fossils found is given and includes one mammal and 3 molluscs now extinct in Britain.

We who joined in the excursion to this place can readily see the value of the section at Swanscombe, in showing us the danger of basing conclusions on negative evidence. A deposit (the gravel of the high terrace) thought to be practically unfossiliferous has proved to be, at one place, particularly rich in fossils, so as indeed to be comparable with the Crag, and a species of mollusc that had never been found in any beds older than the Alluvium occurs there in abundance, with its colouring well-preserved, nearly 100 feet above the present river.

1900.

M. A. HINTON. Correlation of River Terraces.*

Refers to the Thames Valley. He says that "the surface levels are essentially unreliable when taken over large areas," and concludes that "the mean level of the surface of each of the platforms upon which the Pleistocene strata of the different terraces repose" is the safer guide. As the greater part of the Valley Drift rests on London Clay this basal plane will have been less subjected to subterranean erosion than would be the case with calcareous beds.

1901.

T. V. HOLMES. Geological Notes on the New Reservoirs in the Valley of the Lea, near Walthamstow, Essex.†

An account of the sections that have been visited by us and by the Essex Field Club, but which I believe are not wholly in Essex, as the title might lead one to think.

The gravel of Higham Hill is described and classed as belonging to the ancient Thames rather than to the Lea, with other high gravels.

The cuttings for the reservoirs were through Alluvial beds to the underlying gravel, the former consisting of clay, loam, peat, and shell-marl in varying amounts, the claycy beds alone being present in many places. Details and figures (6) are given, some showing various irregularities in the beds. London Clay was reached at greater depths in trenches.

At one part an old channel of the Lea was cut across, and near this were found the remains of an old vessel, described in the newspapers as a Viking ship.

Speaking generally of the sections, the author says that "the

* *Science Gossip*, n. ser., vol. vii, no. 74, pp. 62, 63.
† *Essex Naturalist*, vol. xii, nos. 1-6, pp. 1-16, pl. i.

constant constituents of any section are the loam or clayey loam at the surface and the gravel towards the base. Their respective thicknesses may vary, but where they only are present the gravel always makes a larger proportion of the whole section than where peat, or more or less peaty clay or mud, with shell marl, intervene between them. And it seems clear to me that the gravel has always been brought down in the channel of the stream; and that the surface loam is the mud which has been deposited on the surface during floods and very high tides." I am inclined to think that there is an appreciable interval in age between the two deposits. "Where, between the gravel and the loam, there is a considerable thickness of peat, the plants, the remains of which compose it, having grown in situ, there shallow backwaters must have existed in which the plants grew."

The author draws attention to the fact that "sections in river deposits may show fossil remains of very different ages at the same depth below the surface and only a few feet apart from each other."

A figure and plate of the dug-out boat (which many of us saw) are given It was found resting on a thin bed of sandy silt, with freshwater shells, about 6 feet down, and next overlying gravel. Mr. Holmes remarks that "the articles used by man found in these recent river deposits date from perhaps B.C. 500 to the present day."

These sections well illustrate "how incessantly a river in its windings tends to change its course, and yet how often a spot a few yards from a recent or existing channel may have remained unmodified for centuries."

A. S. KENNARD and B. B. WOODWARD. The Post-Pliocene Non-marine Mollusca of the South of England.*

A general paper on the subject, in which, under *Holocene*, the following localities are referred to:—Kew, Blackfriars, Ladywell (Lewisham), Charlton and Crossness (all Alluvium), Greenhithe (rainwash), pp. 216-8, 221, 222; under *Pleistocene*, Crayford and Erith, and Swanscombe, pp. 237-9.

The Post-Pliocene Non-marine Mollusca of Ilford, Essex.†

"All the old collections were made in the Uphall Pit, where the shells were abundant," but lately another pit has contributed, though more sparingly. The lists from the two pits show "a total of fifty-seven species, being the largest number known from any Pleistocene . . deposit" in our district.

* *Proc. Geol. Assoc.*, vol. xvii, pt. 5, p. 213.
† *Essex Naturalist*, vol. xi, nos. 13-18, pp. 213-215.

There are still three old records that need confirmation.

JOHNSON, J. P. Additions to the Palæolithic Fauna of the Uphall Brickyard, Ilford, Essex.*

A continuation of the paper of 1899. "Foreign materials were conspicuously abundant" in the gravel, and amongst them pebbles of quartzite like those that occur in the Blackheath Beds. The new finds include an Ostracod, seven species of Mollusca, a fish (roach), two rodents (common field-vole, and another), and man, by his implements.

Palæolithic Implements from the Low-level Drift of the Thames Valley. Chiefly from Ilford and Grays, Essex.†

The same author has given an account, with figures, of implements from the above places, and from Crayford, which last indeed seems to have as good a right to a place in the title as the others.

From the figure of a specimen from Ilford, it seems to me hardly safe to class it as a saw; it is a notched flake. A like doubt may be expressed as to one of the Crayford specimens being a spear-head. I always feel shy of attributing a special use to these flakes; it may be questionable whether man became a specialist so early.

It is satisfactory to know that the Essex specimens have been given to the Essex Field Club's capital Museum.

M. A. C. HINTON and A. S. KENNARD. Contributions to the Pleistocene Geology of the Thames Valley. 1. The Grays Thurrock Area, part 1.‡

The authors give a Bibliography, from 1836 onward, of 75 works. They then treat shortly of the High Terrace Drift, and at rather greater length of the Middle Terrace Drift. Palæontology takes up 14 pages, and Physiography 9.

Under this last attention is drawn to valleys which occur over the plateau. These are rather "shallow grooves of about thirty feet in depth, varying from a quarter to half a mile in breadth and about three-fourths of a mile to one mile in length." They are not due to fluviatile or subaërial erosion as they do not cut through the gravel, and it is unlikely that they could have been cut in Thanet Sand before the deposition of the Drift, as they would have been filled up. The evidence points to their being "the result of the underground dissolution of the Chalk by water charged with carbonic oxide and organic acids acting along a more

* *Essex Naturalist*, vol. xi, nos 13-18, pp. 209-212.
† *Essex Naturalist*, vol. xii, nos. 1-6, pp. 52-57.
‡ *Essex Naturalist*, vol. xi, nos. 19-24, pp. 336-370.

or less definite line of weakness," and it is argued that the tension of the anticline "has been great enough to open fissures in the Chalk."

The conclusion that from the fact of the High Level Terrace being about 100 feet above the present river, the land must have been so much lower when that terrace was formed, seems to me to be based on the assumption that the level of the river was then as now. I am inclined to think that the whole country, river and all, was much higher then; otherwise how are we to get a stream powerful enough to carry along great masses of gravel? as rainfall and consequently streams increase with height of land. That the saturation-level in the Chalk was higher and therefore the dissolution of the Chalk more easily effected, as the authors argue, is likely, for the valley had not been cut to its present depth and therefore the outlet for water must have been higher, but this does not need depression of land.

In their Conclusions the authors give up the idea that the climate of the High Terrace period was "of considerable rigour." Though there is evidence of river-ice, yet as these deposits have yielded "a fauna as rich as that of the brickearths at a certain locality in Kent, it seems that the view of an exceedingly cold climate is hardly tenable now." Rather is the climate thought to have been "very similar to that of the present day." It is easy to understand how the evidence of the Swanscombe section (alluded to above), with its rich molluscan fauna, has led to change of view.

In taking leave of these energetic observers one is tempted to ask whether they mean to leave anything for others to observe in this particular branch of London geology.

1902.

G. CLINCH. Swanscombe and Stone.*

These "Archæological Memoranda" contain a reference to the gravel of Swanscombe and Greenhithe, and to the implement found therein, with two figures (pp. 21, 22).

Some papers, by E. A. MARTIN (1898, 1900) having been noticed in another address,† need not be referred to.

3. EOCENE.

Leaving the Drift it is not a little strange that the Geological Society's Journal of the past 13 years contains no paper on the Eocene Tertiaries of London, and that the Geological Magazine follows suit, going even further and leaving us altogether alone even to the lowest geologic depths.

* *The Reliquary*, vol. viii, no. 1, p. 21.
† *Proc. Croydon Micr. Nat. Hist. Club*, p. lvii (1901).

The reason may be two-fold, in the first place that whilst old sections of these beds are apt to get hidden, new sections are not often opened; and in the second that our knowledge of the older Tertiary beds is comparatively perfect; so that problems of great interest are less likely to arise with them as with the Drift. Of this latter on the other hand we are constantly having new sections and new views, there being much more scope for imagination and far less certainty as to stratigraphic succession amongst these ever varying deposits. The geologic mind turns naturally to subjects that promote discussion, and the Drift is likely to supply this healthy appetite with food for a long time.

One may perhaps be allowed a pleasant feeling, that the Eocene Tertiaries have been pretty thoroughly described, and that everybody knows all about them.

The papers to be noticed chiefly refer to details of new sections, and there is no more to be said about the work of 13 years, in this case, than about only last year's papers on Drift and Recent beds. Other details of course are to be found in papers on well-sections, to be noticed under another heading.

1889.

PROF. J. L. LOBLEY. Hampstead Hill: Its Structure, Materials, and Sculpturing. Small 4to, London.

Largely reproduced from newspaper-articles, and from a paper to the Middlesex Nat. Hist. Soc., this little book gives a general account of the geology, four chapters being devoted to the London Clay, and a chapter to the Bagshot Sand. The sculpturing and the substructure are then treated of, followed by a list of fossils of the London Clay and a geologic bibliography.

1890.

H. M. KLAASSEN. The Pebbly and Sandy Beds overlying the Woolwich and Reading Series on and near the Addington Hills, Surrey.*

A record of the section made along a line of sewer 1,636 feet long, through Blackheath Beds and Woolwich Beds, of which details, at various parts, are given.

On the top of the Addington Hills a thickness of 50 feet of Blackheath pebble-bed was found in a trial-boring, and Dr. Hinde contributes a note of the section shown in the reservoir. He "did not see a single example of a flint retaining its original, subangular form . . . and the only exception to the prevalent flint-pebbles . . . were some . . . pebbles of a light-grey quartzite. . . . Judging from the character of the rock, they may have been derived from Palæozoic strata,

* Proc. Geol. Assoc., vol. xi, no. 8, pp. 464-472. Part reprinted in Trans. Croydon Micr. Hist. Soc., vol. iii, pp. cxliv, cxlv.

and it is not easy to account for their presence in these Tertiary pebble-beds." It is added that they are rare: and my own experience accords with this, for it is generally held in Croydon that Dr. Hinde has collected every visible specimen in every section of the beds.

An analysis of a pipe-clay in the Oldhaven Sand is given.

1891.

C. D. SHERBORN and H. W. BURROWS. Report on the Microscopical Examination of some Samples of London Clay from the Excavations for the Widening of Cannon Street Railway Bridge.*

T. LEIGHTON and J. B. OGLE. On some Recent Sections at Dulwich.†

Having noticed these papers in another Address,‡ they may be passed over here.

R. B. NEWTON. Systematic List of the . . . Edwards Collection of British . . . Eocene Mollusca in the British Museum. 8vo, London.

Although a general work, referring to the whole of the London and Hampshire Basins, yet this should be noted here, from its frequent reference to London localities, especially to Highgate.

1897.

DR. H. F. PARSONS. Geological Notes on a Recent Sewer Section at Park Hill Rise, Croydon.§

The cuttings showed London Clay on the north, from beneath which Oldhaven Beds rise up to the higher ground southward, the pebbles of these being in part "compacted by calcareous matter into a conglomerate bed," at one place 5 feet thick. At the south-eastern end of the section, a fault brings up mottled clay of the Reading Beds, associated with or underlain by shelly clay, and overlain, at the end, by shelly sand, with pebbles (Oldhaven Beds).

1900.

Summary of Progress of the Geological Survey . . . for 1899.

On p. 140 is an announcement that MR. C. REID has been led to think that the high level pebbly gravel of the Stanmore district is Eocene rather than Drift, mainly because it resembles gravels, in the far west of the Hampshire Basin, that seem to be Eocene. I must demur to this conclusion, as the said gravel *is*

* *Proc. Geol. Assoc.*, vol. xii, no. 1, pp. 4-7.

† *Ibid.*, pp. 8-15.

‡ *Trans. Croydon Micr. Nat. Hist. Club*, vol. v, p. vi (1900).

§ *Trans. Croydon Micr. Nat. Hist. Club*, vol. iv, pp. 207-213, plate (section).

not like the undoubted Bagshot pebble-beds of the London Basin (eastward), or those of the Hampshire Basin (westward), and I think that we should for the present adopt the Scotch verdict "not proven" for a conclusion which, as it is said, must affect "the geological age of the whole of the supposed high-level Pleistocene gravels around London."

4. CHALK.

1889.

The REV. G. BAILEY. Foraminifera and other Micro-organisms in Flint. *

A notice of occurrence in "a white silicious meal" contained in hollow flints from the neighbourhood of Downe. Polyzoa, Sponges and Entomostraca were found; but none of the species are recorded.

1894.

F. CHAPMAN. Note on some Microscopic Fossils from the Chalk of Swanscombe.†

26 species and varieties of Ostracoda and 48 of Foraminifera were got from a sample taken at one of our excursions. One Ostracod was new to British Cretaceous beds. It is interesting to find an excursion bearing good fruit speedily.

Let us hope that Mr. Chapman will do as good work in Australia, where he has just gone, as he has done in England.

1900.

G. E. DIBLEY. Zonal Features of the Chalk Pits in the Rochester, Gravesend, and Croydon Areas.‡

The Gravesend tract (pp. 485, 489) is in our district. All the pits are in the zone of *Micraster coranguinum*. The Croydon Area has been referred to elsewhere, as also has the paper by W. M. Holmes, on Radiolaria from the Upper Chalk at Coulsdon.§

And this, as far as I know, is all we have had about the London Chalk (in a wide sense), except for incidental remarks in various papers, for accounts of excursions and for accounts of wells! Much has certainly been written about the Chalk of late years; but the Chalk of London has not formed the text, presumably because it wholly or almost wholly belongs to one horizon of the Upper Chalk. The forthcoming Geological Survey

* *Trans. Croydon Micr. Nat. Hist. Club*, vol. iv. pp. 147-149.
† *Proc. Geol. Assoc.*, vol. xiii, no. 10, pp. 369, 370.
‡ *Proc. Geol. Assoc.*, vol. xvi, pt. 9, p. 484.
§ *Trans. Croydon Micr. Nat. Hist. Club*, vol. v, p. lviii (1901).

Memoir on the Chalk, by Mr. Jukes-Browne, will summarise all our knowledge on the subject, and add to it.

Having now done with our subject, as seen at the surface, we may turn to things that we cannot see, except with the eye of faith.

5. UNDERGROUND GEOLOGY.

Were it not for the facts that many wells have been made, that there is considerable interest in the subject of water-supply from underground sources; and that discussion occasionally breaks out on the question of the old rocks beneath us, I should have been unable to make this address of the proper length. Having worked on all three lines, I might perhaps have gone into much more detail; but I am merciful.

1889.

E. LOVETT. Report on the New Well at Addington.*

A general account of the work. "The Chalk excavated from the well contained a few fossils and varied much in density and character. . . . The last bed of flints was met with at 152 ft. from the surface, at which depth the Chalk was without fissures, dense, and dry. In excavating the headings numerous water-bearing fissures were cut. . . . The fissures in several instances contained brown argillaceous matter, probably introduced in part by percolation from the surface . . . and in part due to the dissolving action of water on the Chalk leaving the insoluble clayey matter behind."

T. WALKER. Well Gaugings in the Croydon District.†

Tables of frequently recorded water-levels in 20 wells, from 1883 to 1888.

1890.

W. WHITAKER. Coal in the South East of England.‡

Although a general paper, there is considerable reference to London, and two sections are given shewing the old and the new view of underground structure.

1891.

PROF. A. W. RÜCKER and PROF. T. E. THORPE. Magnetic Survey of the British Isles.§

This detailed paper refers to the underground range of older rocks beneath us, as one of "two regions of attraction which are not connected with basaltic rocks on the surface, at all events as

* *Trans. Croydon Micr. Nat. Hist. Club*, vol. iv, pp. 152-154.
† *Ibid.*, pp. 198-201.
‡ *Journ. Soc. Arts*, vol. xxxviii, no. 1953, p. 543.
§ *Phil. Trans.* A, vol. 181, p. 53.

the main cause of their peculiarities." This one "runs westward from London to the South Wales Coal-field . . . the line is most clearly marked right across England, and its general direction is such as to make it almost impossible to avoid the conclusion that it is connected with the palæozoic ridge, the existence of which . . has been proved by deep borings near London, and which is supposed to connect the Welsh and Belgian Coal-fields."

"If the palæozoic rocks are nearer the surface here than elsewhere, the crystalline rocks may approach it also within a moderate distance, and if they are susceptible to magnetisation the observed results would follow."

Surely this is a notable case of the possible bearings of one line of research on another of a wholly different character.

J. HOPKINSON. Water and Water-supply, with special reference to the Supply of London from the Chalk of Hertfordshire.*

As the facts chiefly referred to in this paper are outside our district, one need only say that it gives a good account of the subject, from the fall of the rain to the flow of underground water, and that its object is to enter a protest against London taking any further supply from Hertfordshire.

There is a discussion on pp. xlviii-li (1892), and on pp. xxxix-xli the lowering of the water-level is referred to.

J. T. HARRISON. On the Subterranean Water in the Chalk Formation of the Upper Thames, and its Relation to the Supply of London.†

This important paper of course is concerned mostly with tracts beyond that with which we are now dealing; but it is throughout of London interest.

In the long and elaborately reported discussion many of the author's views were much criticized, and, as I took part in it, there is less need to repeat the process now. I must however question the accuracy of the map of the Chalk gathering ground of the Wandle (p. 8), which gives too even boundaries, both east and west, and includes the slope of the escarpment on the south, whereas the rain falling on that slope does not go northward to the Wandle, but southward to springs that contribute to the Mole.

Although the great sheet of gravel in the bottom of the Thames Valley below Windsor must contain a great deal of water,

* *Trans. Herts. Nat. Hist. Soc.*, vol. vi, pt v, p. 129.
† *Proc. Inst. C.E.*, vol. civ, p. 2, pls. 1, 2.

yet it seems too much to say that "it forms at once a large gravel reservoir and an underground river" (p. 14), the latter term being misleading. Probably hardly any one will agree with such a conclusion as that enough water "might be withdrawn from this underground source for the public supply of London and its suburbs for centuries to come" (p. 16).

In the discussion a more or less geologic part was also taken by J. LUCAS, S. CRIMP, Sir J. EVANS, W. TOPLEY, PROF. DAWKINS, PROF. HULL, Sir J. PRESTWICH, and T. M. READE.

W. WHITAKER and PROF. A. H. GREEN. London Water Supply Enquiry. Preliminary Report on the Possibility of obtaining a Supply of Water for London within the Thames Basin. 8vo, Lond., pp. 20.

This is a general Report to the London County Council in advance of further and more detailed enquiries. Unfortunately it was not dated

It points out that in the Tertiary part of the valley of the Thames the character of the ground is unsuitable for making large storage-reservoirs by means of dams.

Since then however the ingenuity of Messrs. Fraser and Hunter, of the Grand Junction Water Co., has got over this difficulty, by designing comparatively shallow reservoirs, partly dug out and partly banked up, in which large storage can be made, and which have the additional advantage of giving good sections through the gravel of the flat to the London Clay beneath, as we saw on our Excursion to Staines.

The general character of the Chalk, in regard to water-supply for London, is discussed, and also the questions of supplemental supplies from the Lower Greensand and from the Gravel.

BINNIE [SIR] A R. London Water Supply Enquiry. Engineer's Report on the London Water Supply from the Thames and Lea. 8vo, Lond.

Another Report to the London County Council. It refers to "Chalk and other Spring Water," and to the lowering of the plane of saturation in the Chalk.

W. H. DALTON. The Undulations of the Chalk in Essex.*

The object of this paper is to shew the depth of the top of the Chalk beneath the older Tertiary beds.

On the map the depth to the Chalk, referred to Ordnance Datum, is marked by contour-lines for every hundred feet. "The

* *Essex Nat.*, vol. v, p. 113, pl. iii. (map).

straighter lines are faults whose existence is imperceptible on the surface of homogeneous clay, even where not concealed by drift, but which are sufficiently established by their effect on the Chalk contour-lines." There are many of these hidden faults, with long ranges in several cases.

Between Chigwell, Havering and Romford is a triangular tract enclosed by faults and much affected by short parallel faults, and the author thinks it probable that this tract "was crushed into its present structure of anticline and syncline by pressure from the north-west acting obliquely to the earlier fracture between Walthamstow and Romford."

The author suggests that some of the folds may have resulted from the slipping of the Chalk and Tertiaries over the surface of the Gault toward the line of depression of the London Basin, after great erosion of the upper beds. There seems to have been a hill range in S. Essex, above the Glacial sea, where now there is no such feature, proving great denudation or differential subsidence.

1892.

J. W. GROVER. An Explanation of the London Water Question.*

Gives a general account of the subject and makes special reference to the valleys of the Colne and of the Mole for additional supply.

The statement (p. 207) that "the springs and wells [used for supply] are wholly situated in the valley of the Lea in the chalk, and in Kent" is not strictly accurate, as it might lead one to think that the wells in the valley of the Lea are all in a chalk-tract, instead of being for the most part carried through Tertiary beds to the Chalk. But in saying that wells "can only be brought in as a supplemental supply," the author is clearly right, albeit that supplement is very valuable, and the Kent Co. has no other source of supply.

An account of the passage of water into and through the Chalk is given; but in saying that the water in the Chalk flows "especially along the layers of the flint beds," and that "it is found that the water is contained in layers or seams of flints," the author errs; for, as a general rule, the nearly vertical joint-planes are of much more importance.

The whole of the Chalk of the Colne Basin is by no means "practically bare," as much of the surface-clay that is of such general occurrence is thick enough to prevent direct access of rain to the Chalk, and all of it hinders access. To treat the great Chalk tract as if it were bare Chalk will not do at all, as had been shown in various papers of earlier date.

On the whole the author seems to take a far too sanguine

* *Trans Surv. Inst.*, vol. xxiv, pt. vii, p. 195.

view of the capabilities of the valleys of the Mole and of the Colne, and his conclusion that the water-supply of London could be supplemented by wells in those valleys to an extent enough for 100 years is clearly unreasonable, for larger extensions than those valleys could supply have already been made or are in progress.

T. V. HOLMES. On the Popular Tradition that Coal exists under Blackheath.*

A kindly attempt to explain the origin of the idea, which, like many such, is based on anything but reason. One of the fullest references to the subject seems to be in a History of Northumberland.

E. A. MARTIN. Amidst Nature's Realms.

This work contains a chapter, "Shall we find Coal under London," which gives an account of the evidence of deep borings.

During the progress of the enquiry of the Royal Commission on Metropolitan Water Supply, various statements were printed and submitted to that body. Of these, some found a place in its Report (see 1893), but some did not, possibly from being of a more or less confidential character. There can however be no harm in alluding to the geologic references in such of these as I have seen.

The Southwark and Vauxhall Water Co. printed, in 12 folio pages, "Geological Reports" by Prestwich (1878), Ansted (1878), Lucas, and Ramsay (1879), dealing with the question of getting water from wells in the Company's district.

RAMSAY points out the likelihood of wells in the Tooting area being affected by a large well being made in the neighbourhood, as has turned out to be the case, through the Streatham well.

LUCAS says that there are only three districts within the Company's boundaries that are worthy of consideration, Tooting Graveney, near Herne Hill, and Peckham Rye.

There are two anticlinals, one from Richmond to Kennington the other through Merton to Peckham, where they join an continue eastward to the Deptford fault.

The water in the Chalk flows along the anticlinals, and "t effect of the deep-seated synclinals is to let down moles as it we of impervious tertiary strata, which, by acting as sluices on descending springs, induce an accumulation of water or head the anticlinal above," so that the water gets "a tendency escape laterally . . along the anticlinal." This is an illus tion of the effect of underground structure on the flow of wate

The Tooting area is suggested as the best for boring down

* *Science Gossip*, no. 332, pp. 180-182.

Lower Greensand. Now however we know that this formation has thinned out somewhere southward.

ANSTED on the other hand recommends a site near Merton as better for reaching Lower Greensand; but he is sanguine in thinking that there "water might be obtained from the chalk at 200 feet from the surface, but to reach the greensand would require a further boring of at least 500 feet," for at the well in Merton, where the Chalk is nearest the surface (164 feet down) it would need some 600 feet more boring to reach only to the bottom of that formation, leaving still some 200 feet of Upper Greensand and Gault to be dealt with. Moreover most of the wells thereabout do not reach the Chalk at 200 feet.

PRESTWICH advises that to get a large supply "it would be necessary to carry down a shaft to some depth in the chalk, and then in case of need, to drive galleries until a certain number of water-bearing fissures were opened out." It is true that by good luck (and it is nothing else) a large boring may get a good supply, as has been the case at Streatham; but in this, as in many other matters, I often find myself following in this master's footsteps.

He discusses the underground extent of the old ridge (or rather slope) against which the Lower Greensand thins out; but is misled by the unlucky determination, as belonging to that formation, of beds which we now know to be Jurassic, at Meux's Brewery, and he is thereby led to recommend a site near Nunhead for reaching Lower Greensand.

Another print, of 4 folio pages, is a "Report upon the Underground Supply of the East London Water Company and its possible extension," by our former president, W. TOPLEY, who notes the four existing wells and considers that in the Lea Valley other successful wells may be made [as they have been], getting water both from the Chalk and from Lower Tertiary sands.

"Here, as elsewhere, where Sands rest directly upon the Chalk, it is impossible to separate the two water-systems, and much of the water found in the Chalk is probably derived from the Sands." He thinks that the supply from the sands may be extended at Lea Bridge, where there is a small anticlinal "over the top of which the London Clay has been removed, and here the gravels of the river rest upon the Lower Tertiary Sands," and he sees "no reason why the gravel-water should not thus be largely utilised indirectly."

He says: "The underground chalk-water of the Lee Valley is so enormous that the highly productive wells there now at work seem not to affect each other. There is no reason to suppose that the limits of supply are as yet nearly reached. The wells are tapping the water which flows south-eastwards towards the lower part of the Thames. It is impossible to say what this amount of water may be; but until its limits are approached by underground works, wells in the lower part of the Lee Valley will have no effect upon the water at or near the outcrop of the Chalk." These remarks are quoted in full as being a clear statement of a view with which I am not altogether in accord. It seems to me that we have yet to learn much on this very debatable subject.

Although the Tables of Areas of Geological Formations in the Basins of the Thames and of its Tributaries, also by my old friend and colleague Topley, are printed in the Report of the Commission in a tabular form, yet the original work, in 67 folio pages (with many MS. additions), is so much more handy that I feel bound to notice it, for it is one of the most valuable pieces of practical geologic work that I know of. As all these Reports, however, must be somewhat inaccessible, no apology is needed for alluding to them at some length.

1892, 3.

E. A. MARTIN. On the Underground Geology of London.*

A general discussion of the question. Two sections, from Ware to southward of Caterham Waterworks, shew two readings of the older rocks, especially as regard the interpretation of the doubtful red beds, at Kentish Town and Streatham. Another section is from Burford through London to Dover, and a fourth, from Burford through Ware to Harwich, avoids London. A smaller one from Richmond through Streatham to Crossness shows the easterly thinning out of the Lower Greensand and of the Jurassic beds.

1892-1901.

Some Essex Well-sections (Part iii and Part iv).†

Some Middlesex Well-sections.‡

Some Surrey Wells (Second Paper and Third Paper).§

To shorten the story one may group these five papers of my own. They are of the driest, though connected with water, and it is enough to say that they add about 100 to our store of London sections. There are many more in hand.

1893.

An Account of the Artesian Well . . . at New Street, Gravel Lane, Houndsditch . . . 8°, pp. 47, Section in 3 folding plates.

In this Report to the Commissioners of Sewers of the City, a fuller account of this well is given than had appeared before. The geologic classification, however, is a little out, the Thane

* *Science Gossip*, no. 335, pp. 251-254, and no. 337, pp. 11-15, 22.
† *Essex Nat.*, vol. vi, p. 47, and vol. ix, p. 167 (1896).
‡ *Trans. Brit. Assoc. Waterworks Eng.*, vol. ii, p. 76 (1898).
§ *Trans. Croydon Micr. Nat. Hist. Club* (1895), p. 132 and (1901), p. 30

facts; but its chief conclusion (that London could be supplied from the Lower Greensand) is wrong, and mainly because fresh facts have turned up which clearly lead to the reverse view. But the error of the conclusion does not detract from the goodness and value of the work as a whole. Certainly it never lessened my own high regard for the author's contributions to our science.

1896 (or 7 ?)

C. H. COOPER. Ownership of Underground Water.*

Refers to the law of underground water and to the effect of the pumping at the Streatham well, of the Southwark and Vauxhall Water Co., on many wells in the Valley of the Wandle, which have been more or less dried up.

1898.

PROF. W. B. DAWKINS. On the Relation of Geology to Engineering.†

Besides a general account of water in the Chalk, largely as regards the supply of London, there is a notice of the lowering of the water-level in the Chalk under London, illustrated from wells Hampstead and St. Pancras, and a figure of the cone of exhaustion of the Surrey Street Well at Croydon.

Having failed to notice this lecture in either of my Croydon addresses, I am glad to call attention to it now.

MARTIN, E. A. New Borings round London.‡

Gives a detailed account of four wells in London, of which, however, only one (Soho Square) was new.

1898, 1899.

ANON.: Water Supply from the Chalk.§

Although a newspaper-article, and therefore beyond the literary area that I have felt bound to consider, as noted in my Address of last year, one may fairly notice this, as it is clearly written by some one who is not ignorant of geology. It is always satisfactory to find something worth reading when scientific matters are treated of in a newspaper.

The writer recommends that a thorough investigation should be made, and says, "The work can only be carried out by a properly organised survey, and under Government control, and such a survey would be worth a dozen Royal Commissions, and much cheaper." With the former part of the opinion as to the value of the work I am disposed to agree, but I am not so sure

* *Journ. San. Inst.*, vol. xvii, pt. iv, p. 585.
† *Proc. Inst. C.E.*, vol. cxxxiv, pt. iv.
‡ *Science Gossip*, n. ser., vol v, pp. 118, 119.
§ *Builder*, vol. lxxv, p. 545, and vol. lxxvi, p. 29.

as to the conclusion. It would be a very big undertaking, and must last for a long time: therefore it would cost much. Anyhow it is satisfactory to have actual survey suggested as the right thing, instead of more talk.

In the disquisition on the water-bearing character of the Chalk, the Lower Chalk is apparently taken in the old sense, including what we have long known as Middle Chalk, nearly half the Chalk being classed with it. Until our terminology is settled it is clearly impossible to discuss such a question as the water-bearing character of any division of the Chalk. The writer properly objects to the Lower Chalk being taken as "entirely impervious."

It is news to me to hear the Geological Survey map described as "made to show the distribution of fossils more particularly," for I have no recollection of having more particularly done work of this kind during my service of nearly forty years. Every surveyor knows that he has constantly to map, without any help from fossils.

The second part refers more especially to Hertfordshire and Kent. A third part, on Essex, was promised, but I believe has not been published. I am disposed to admire the author's discretion in leaving that county alone.

1900.

Even in so short a time as that with which I am dealing there was a second official enquiry on our Water Supply, the Royal Commission on Water Supply within the limits of the Metropolitan Water Companies; but I am thankful that its voluminous Report, Minutes of Evidence, and Appendices contain little of geologic interest. In the evidence given by J. FRANCIS, W. B. BRYAN, SIR J. EVANS and myself there are remarks concerning wells and water-levels; but the only matter that need be definitely mentioned is the "Table showing Average Daily Quantity of Water supplied from Springs and Wells in the Lea Valley during each month" from 1892 to 1897, on p. 34 of the Appendices. The highest daily average was reached in 1895, and amounted to over 20¼ million gallons. Few people perhaps realise the enormous quantity of water that is got from wells, for London. To the figure above quoted must be added the whole of the Kent Co.'s supply.

ANON. and E. A. MARTIN. Some Deep London Borings Some Deep Borings in London.*

In continuation of the note of 1898. The first notices 1[illegible] borings, some of which had already been published in detail, whilst others have since been. A like remark holds with the second.

* *Science Gossip*, n. ser., vol. vii, no. 74, p. 62, and no. 78, p. 186.

A. J. JUKES-BROWNE. Memoirs of the Geological Survey. The Cretaceous Rocks of Britain. Vol. i. The Gault and Upper Greensand of England.

The part of this book that refers to London is chap. xvi (Subterranean Extension of the Gault and Upper Greensand), in which the beds proved in the various deep borings are noticed, including those of Meuxs, Kentish Town, Loughton, and Cheshunt, but omitting that at Streatham.

The author says, "With respect to variations in thickness of the formation as a whole [The Selbornian, or combined Gault and Upper Greensand], between Windsor and London it thins continuously eastward." But "in a northerly direction we find the thicknesses are more irregular," 188 feet under London, 144 feet at Kentish Town, and 206 at Loughton.

"These facts suggest the inference that this portion of the sea-floor rose into an east and west ridge below Kentish Town, that the Jurassic rocks thinned out against the southern border of the ridge, and that though it sank beneath the sea of the Gault, less of that material was deposited on the ridge than in the presumably deeper water to the north of it."

DR. P. L. SCLATER described the new boring at the Zoological Gardens, which was carried 258 feet in Chalk.*

In my Presidential Address of this year I noticed the range underground of the Cretaceous and underlying formations in the London Basin.†

DR. J. C. THRESH. The Saline Constituents of Chalk Waters.‡

Analyses of waters from wells at Barking and Grays show the admixture of river-water; but nearly all the analyses given are from places beyond our bounds. "The river water entering the Chalk at or near Barking undergoes some change before arriving at the wells," and this opens up an important question as to alterations in the mineral constituents of underground waters.

SOLLAS, PROF. W. J. On a Possible Coalfield in the London Basin.§

Considers that the older rocks "occur in somewhat gently undulating folds," that from the dips at Ware and Cheshunt one

* *Quart. Journ. Geol. Soc.*, vol. lvi, *Proc.*, pp. iv, v.

† *Quart. Journ. Geol. Soc.*, vol. lvi, *Proc.*, pp. lxxiv, lxxxv. Reprinted in *Trans. Inst. Min. Eng.*, 1901.

‡ *Trans. Brit. Assoc. Waterworks Eng.*, vol. iv, p. 24.

§ *Rep. Brit. Assoc.* for 1900, pp. 739, 740. [Wrongly dated as published in 1900. Was not published until 1901.]

can determine the position of a synclinal, that this will be east and west through Enfield Lock, and that a site near Enfield or New Barnet is "the most promising spot for a trial boring."

1901.

Dr. J. C. Thresh. Report on the Water Supply of t[illegible] County of Essex.*

Gives an account of the public water-supplies of the who[illegible] county, and discusses the quality of the water, with ma[illegible] analyses. On p. 28 is a section of a new well at Ilford.

W. W. Fisher. On Alkaline Waters from the Chalk.†

Refers to the different character of the waters from dee[illegible] seated Chalk and of those from uncovered Chalk.

Gives a new analysis of the water from the Trafalgar Squa[illegible] well, and compares the various analyses that have been mad[illegible] showing "as regards the total saline constituents a diminutio[illegible] since 1846, but adding that "since 1857 there is no substant[illegible] change."

Alludes to the various "attempts that have been made explain the abnormal characters of the waters under conside[illegible]tion," but unfortunately omits the most important, that of Pr[illegible] Warington, an omission also made in the Memoir on the Geol[illegible] of London, but in that case by a mere geologist.

Comes to a conclusion that may be described as that of Pr[illegible] Warington (leaching of the Chalk), supplemented by that wh[illegible]ch regards the water as affected by the Tertiary sands, above the Chalk, a conclusion to which I have also come.

Gives an analysis of Chalk from a depth of 500 feet in the deep boring at Meux's Brewery. This specimen and another, from the depth of 800 feet, "contained distinct traces of alkaline carbonate, sulphate and chloride."

I welcome this and other additions to our knowledge from our chemical brethren.

6. VALEDICTORY.

So far we have dealt with what has been done, and though I would not venture to attempt to tell you what ought to be done, yet I should like to call attention to an important line of observation that has only been partially tried, and which seems to give scope for the employment of a good deal of energy. But before doing so I will allude to a smaller matter.

In the process of the reconstruction of our great city, as well as in its growth, there are frequent exposures of the upper crust,

* 8° *Chelmsford*, pp. xv, 168, 12 pls. (maps and section).
† *Analyst*, Aug.

in diggings for foundations, etc. These are dissolving views, and I would venture to suggest that observers who would carefully record any such vanishing sections would do good service. The larger ones, of course, are generally noted, and some of us have managed to see a few of these, at informal excursions. But I want to impress on you that even the smallest section is worth recording, for it is only by the accumulation of information thus given that the surface-geology of a built-over tract can be made out in detail.

We have now a great store of information, from hundreds of wells and borings, of the thickness of various geologic formations beneath our feet. These are contained in various memoirs and papers that are readily accessible; but as yet they are only, as it were, a lot of separate bones, the disjecta membra of a huge skeleton. Even in this state they are of considerable value; but surely they would be of much more interest if someone would build them up into even a very imperfect skeleton. Is it not time that something was done to put our voluminous information together, in a way that would lead to generalisations?

The chief point, perhaps, is the depth to the Chalk. We know that depth, from the surface, in hundreds of places; but the surface is irregular, and to get any useful result it would be needful to reduce this in all cases to a definite standard, which, of course, must be in regard to Ordnance Datum (or mean sea-level).

Then these depths should be marked, at their various sites, on a map, such as the one-inch Ordnance Map.

From the information thus collected, contour-lines of the top of the Chalk, beneath the Tertiary beds, could be drawn, with a fair approximation to accuracy, and from these contour-lines we should not only learn something in regard to the probable depth to the Chalk at places between sites where it has been proved (a point of some practical importance), but also should get evidence of underground saddles and troughs, uprisings and downsinkings of the beds which are not shown at the surface, and of which we know practically nothing as yet.

As far as I know, the only piece of work of this sort that has been published is that by MR. DALTON in Essex, which has been noticed above (p. 352), but I infer that MR. LUCAS also has done something of the sort (see p. 354.) Were I younger, I might perhaps do something towards it myself; but now it is surely enough for me to suggest to some of our younger brethren that there is interesting work to be done in this line. I may be allowed to think that my duty has been done in collecting the data, by getting together and printing all the records of wells that I could lay hands on, published or unpublished.

If I have thus sown the seed, it is for others to cultivate the crop and to gather in the harvest.

And now the end of my task and of my Presidency have come. I look back on my term of office with unalloyed pleasure. The officers have kept me from greatly erring, the rest of the Council have helped me in the right path, the directors of excursions have led me amongst pleasant places, and all of you have encouraged me in my work. A pretty constant attendance at the meetings and excursions has strengthened many old friendships and formed new ones, bringing me the great satisfaction, amongst other things, of being more in touch with younger geologists than would have otherwise been the case. I hope that I may still be able to profit by these advantages, and to do some further work for the Association.

You have elected as my successor one who has done us good service. Whether as lecturer, as leader of excursions, as member of council, or as chairman of the Excursion Committee in its early years, one may indeed say as its organiser, Mr. Monckton deserves well of the Association, and its interests could not be in better hands than his.

I have much pleasure in hailing him as President, and I hope that the office may prove as great a source of satisfaction to him as it has been to me.

VISIT TO THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD.

SATURDAY, MARCH 15TH, 1902.

Director: A. SMITH WOODWARD, LL.D., F.R.S., Keeper of Geology.

(*Report by* THE DIRECTOR.)

A LARGE party, numbering from forty to fifty members, met at the Natural History Museum, for the purpose of inspecting the specimens of Pliocene Mammalia, and other fossils, recently obtained from Pikermi in Greece.

The Director remarked that since the excavations undertaken by the Trustees of the British Museum at Pikermi, near Athens, in 1901, the Department of Geology had been much occupied with the early Pliocene Mammalia. These quadrupeds were of special interest, because they exhibited the last phase in the evolution of the Old World Mammalia before they assumed their present day aspect. They had long been well represented in the Museum by the unique collection of remains from the Siwalik Hills, India, chiefly obtained by Falconer and Cautley. They were also illustrated by Dr. Forsyth Major's collection from the Island of Samos, and by another large series from Maragha, in Persia. The new Pikermi collection, however, was the first noteworthy series of early Pliocene Mammalia acquired by the Museum from the mainland of Europe.

The Director then exhibited a typical selection of specimens from the excavations at Pikermi, describing the nature of the deposit and some of the principal genera of Mammalia discovered in it. He had already published a brief report on the subject in the *Geological Magazine* [4] vol. viii, pp. 481-486 (Nov. 1901).

The red marl at Pikermi seems to have been deposited in a lake, and the fossil bones contained in it occur in definite thin beds, which were first exposed by the eroding action of a modern torrent. There are no complete skeletons, except perhaps of small carnivores, but there are many limbs and portions of backbone which must have been held together by ligaments at the time when they were buried. Most of the bones, however, are detached and broken, and there are numerous small splinters. The animals seem to have been suddenly destroyed, and the bodies were probably torn to pieces by torrential action while being transported to the lake where they were finally entombed. The specimens already exhibited in the British Museum comprise remains of monkeys (*Mesopithecus*), small carnivores (*Hyæna*, &c.), *Rhinoceros*, *Hipparion*, *Ancylotherium*, *Mastodon*, *Sus*, *Giraffa*, and numerous antelopes (*Gazella*, *Palæoreas*, *Tragocerus*, &c.).

After passing a hearty vote of thanks to Dr. Smith Woodward, the party adjourned to the Eastern Gardens of the Museum, for the purpose of inspecting the large Sarsen stone exhibited there. This stone was found about 100 yards eastward of its present position, in excavating the foundations of the Victoria and Albert Museum (now in course of construction). It lay buried about 10 feet below the surface, in a bed of Thames Gravel, about 5 feet thick, above which lay 4 or 5 feet of made ground (old gardens). Colonel C. K. Bushe, F.G.S., a member of the Association, saw it taken out, and presented it to the Natural History Museum authorities, who placed it in its present position. In the unfortunate absence of Colonel Bushe, the President and Mr. W. H. Hudleston, made some interesting remarks on Sarsens, after which the party dispersed.

EXCURSION TO THE GOWER PENINSULA, SOUTH WALES. EASTER, 1902.

FRIDAY, MARCH 28TH, TO WEDNESDAY, APRIL 2ND.

Director: R. H. TIDDEMAN, M.A., F.G.S.

Excursion Secretary: W. P. D. STEBBING, F.G.S.

[The Editor regrets that he has not been able to obtain a report of this interesting excursion. The following account of the general structure and succession of the peninsula, the accompanying figure, and the list of references to maps and literature relating to the geology of the district, are reprinted from the special circular, which was drawn up by the Director and the Excursion Secretary, and was issued to all members before the excursion took place.]

The Peninsula of Gower consists of a compound anticline, running from Mumbles Head on the east to Rhos-sili Bay on the west. The central axis of Old Red Sandstone, resting on Ludlow rocks (lately discovered by H.M. Geological Survey), culminates in Cefn Bryn, a conspicuous centre. Two other spurs of Old Red are notable at the western end. On the north side comes on a succession of Lower Limestone Shale, Carboniferous Limestone, and shales and grits of Millstone Grit age, which, on the north, dip beneath the South Wales Coalfield. To the south the limestone undulates with steep folds and encloses two synclines of higher shales at Oxwich and Port Eynon Bays, as well as at Oystermouth, near Mumbles. At several places decalcified limestones with cherts (Bishopston Beds), some containing Radiolaria, occur between the Carboniferous Limestone and the Millstone Grit shales. These are considered equivalent to the Coddon Hill Beds of North Devon, and form a link across the Severn Sea. Other interesting beds occur high up in the Carboniferous Limestone.

A Triassic outlier has been found at Port Eynon resting on the Bishopston Beds.

The Drifts are very interesting, and in connection with the Bone-caves, which are numerous, show a succession not before realised. This is summarised in the following descending order:

Upper Head, a rock-*débris*.

Glacial Gravels and Clays.

Lower Head, pre- or inter-Glacial, containing in the caves the usual Pleistocene fauna, and resting on

Blown Sand in many places, and in the caves on

Raised Beach.

Modern Blown Sands occur in several parts of the coast.

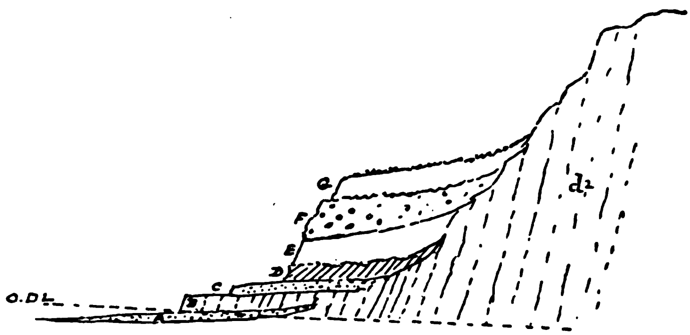


FIG. 55. GENERAL SECTION OF DRIFTS, GOWER COAST.—*R. H. Tiddeman.*

O.D.L., Sea-level.
d^2, Limestone.
A, Present Beach.
B, Raised Beach Platform.
C, Raised Beach.
D, Blown Sand.
E, Lower Head.
F, Glacial Beds.
G, Upper Head.

Of these A and G only are post-Glacial.

REFERENCES.

1-inch Ordnance Survey Map (New Edition), Sheets 246, 247. Price 1s. each.
1-inch Ordnance Survey Map of Swansea and Environs, on thin paper, folded in cover. Price 1s. 3d. Mounted on linen, 1s. 6d.
Geological Survey Map, 1-inch, Sheet 37. Price 8s. 6d.
Geological Index Map, ¼-inch, Sheet 10. Price 2s. 6d.
1846. DE LA BECHE, Sir H. T.—"Memoirs Geological Surveys," vol. i, pp. 133, 134, 146.
1852. BENSON, S.—Account of Bacon Hole. Report of the Swansea Literary and Scientific Society.
1860. FALCONER, Dr. H.—"On the Ossiferous Caves of the Gower Peninsula." *Quart. Journ. Geol. Soc.*, vol. xvi, p. 487.
1863. LYELL, Sir C.—"Antiquity of Man," p. 172.
1872. SYMONDS, W. S.—"Records of the Rocks," pp. 330 to 339.
1887. WOODWARD, H. B.—"Geology of England and Wales," 2nd Edition, pp. 167, 544, 554.
1892. PRESTWICH, J.—"The Raised Beaches and the Rubble Drift of the South of England." *Quart. Journ. Geol. Soc.*, vol. xlviii, p. 288.
1900. TIDDEMAN, R. H.—"Age of the Raised Beach of Southern Britain as seen in Gower." *Trans. Brit. Assoc. (Bradford).*

the bottom. Consequently an open pit for Chalk would involve the removal of very large quantities of the overlying sand, clay, and gravel in order to obtain a comparatively small amount of chalk. And the reason for utilising the Chalk here arose from the fact that the nearest exposures of Chalk at the surface are about four miles away, at Lewisham northward and Orpington southward. While the system here followed does not necessitate the excavation of any material but that desired, it does not interfere in any way with the use of the land above the workings for other purposes. Near the entrance to these caverns may be seen the remains of some kilns. Nothing is known of their date.

After tea at the Bickley Arms Hotel the party left for Chiselhurst railway station, about a quarter of a mile southward.

REFERENCES.

Geological Survey Map, Sheet 6. Price 8/6.
Ordnance Survey Map, New Series, Sheet 271.
1872. ILOTT AND COLES-CHILD.—"Excursions to Bromley and Chiselhurst." *Proc. Geol. Assoc.*, vol. iii, p. 114.
1876. LOBLEY, J. L.—"Excursion to Bromley, Sundridge, and Chiselhurst." *Proc. Geol. Assoc.*, vol. iv, p. 498.
1889. WHITAKER, W.—"Geology of London." Vol. i.
1900-1. HOLMES, T. V.—"Excursions to Grove Park." *Proc. Geol. Assoc.*, vol. xvi, pp. 522, 533; vol. xvii, p 136.

EXCURSION TO COWCROFT.

MAY 3RD, 1902.

Director: UPFIELD GREEN, F.G.S.

Excursion Secretary: A. K. COOMÁRASWÁMY, B.SC., F.G.S.

(*Report by* THE DIRECTOR.)

THE sections as described in vol. xv, pp. 87-89, were in good condition, especially that of the Brickearth in the second section, S.E. of the brickfield, now showing a face of nearly 40 feet and an excavation of about 20 feet, giving nearly 60 feet of pure Brickearth with but little admixture of gravel and that only in the neighbourhood of the Chalk pinnacles. On the west side of this pit the white sand of the Woolwich and Reading Beds had been cut into and exposed.

In the first section, N.E. of the brickfield, a layer of detached flint pebbles was noticed, some of large size, about 6 feet above the base. The Chalk, it was also observed, was filled with borings on its surface as at Harefield. (*Proc. Geol. Assoc.*, vol. xiii, p. 282.)

A welcome tea at Chesham terminated the proceedings.

REFERENCES.

Geological Survey Map, Sheet 7. Price 18s. 6d.
Ordnance Survey Map, 1 inch, Sheet 238. Price 1s.
Record of Excursions, p. 238.
UPFIELD GREEN. "Excursion to Chesham, etc." *Proc. Geol. Assoc.*, vol. xv, p. 87.

a slight greenish tint, there was nothing to suggest the mity of the underlying Woolwich Beds. It seemed therefore nt that the Oldhaven or Blackheath Beds had thickened much south-eastward of Grove Park Cutting, in which they seen by Mr. Whitaker to be about 10 feet thick.* For rds the Chiselhurst end of the tunnel, little more than half a away, they were certainly 40 feet thick, at the least, even the greenish beds, which were the lowest seen, were not ded. But though there was no evidence that the lowest seen belonged to the Woolwich Series, beyond the slight imption arising from their greenish tint, Mr. Whitaker in was more fortunate. In the Memoir already mentioned, he s that in that year, at the southern mouth of the old tunnel, r yards eastwards, more than 40 feet of Blackheath Pebble appeared. He adds that they rest "on the bottom bed ie Woolwich Series, the shell beds having been eroded " (vol. i, p. 224), and on p. 227 the section at the mouth of ld tunnel is figured, the lowest bed being described as the ttom-bed of the Woolwich Series: Green sand with pebbles, eet shown." Thus, while northward the clay shell beds of the lwich Series exist in considerable thickness at the new house at Grove Park, are visible in Grove Park Cutting, and rell developed southward in the Orpington Cutting, as we seen, and as Mr. Osman's section shows (*Proc. Geol.* ., Aug., 1901), they are absent at the Chiselhurst end of unnels. On the other hand, the Blackheath Pebble Beds nuch thicker at Elmstead than either at Grove Park or igton.

any shells were to be seen in the pudding stone, but few be extracted without injury. Oysters were numerons. But list of fossils it seems best to refer the reader to that given r. Whitaker in the Memoir before mentioned, as having been l in the Sundridge "rock-pit" a few yards away.

e party then went towards the Bickley Arms Hotel, at the of which some extensive old workings in the Chalk were cted, which do not appear to have been previously visited ie Association, though the similar caverns at the end of len Park were the scene of an excursion on April 22nd, 1876. also Whitaker's Memoir, vol. i, p. 116.) They consist of ges driven into the Chalk and connected by others ranging rections nearly at right angles to the first. Their height ; from about 7 to 10 or 11 feet, apparently with ieight of the flint band or hard and compact bed of : suitable for a roof. The reason for the adoption here of nethod of excavating the Chalk arises from the fact that the anticlinal fold, which brings the Chalk to the surface in the ' north of Chiselhurst station, allows it to appear only at

* See *Geology of London and Part of Thames Valley*, vol. i, p. 226.

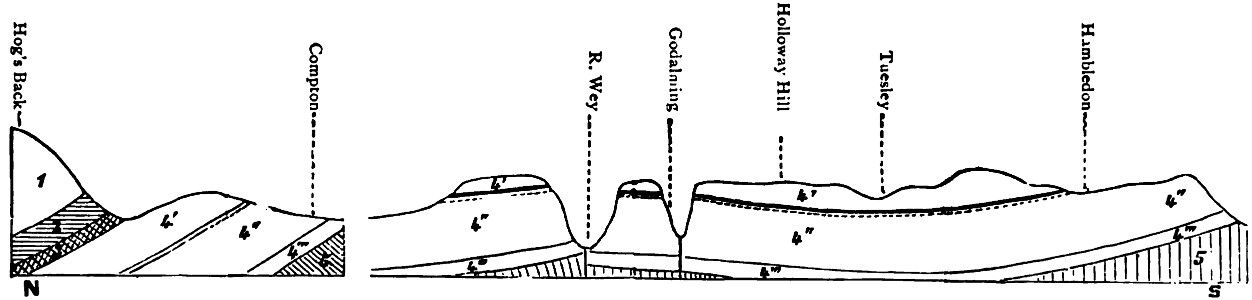
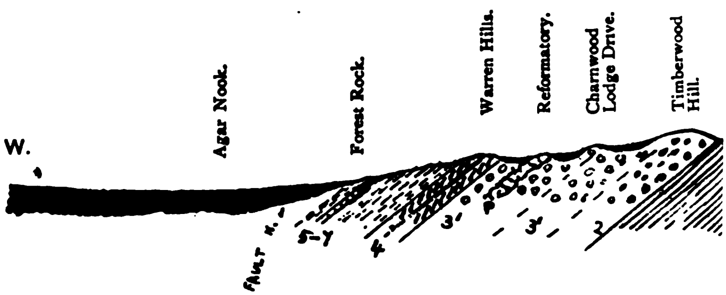


FIG. 56. SECTION THROUGH GODALMING FROM NORTH TO SOUTH.

1. Chalk.
2. U. Greensand.
3. Gault.
4'. Folkestone Beds.
4". Sandgate and Hythe Beds.
4'''. Atherfield Beds.
5. Weald Clay.

NOTE.—The "fault" shown in this section as occurring near Compton is greatly exaggerated, and, though certainly existing at this point, might have been better represented by a sudden bend or anticlinal.


W.
Agar Nook.
Forest Rock.
Warren Hills.
Reformatory.
Charnwood
Lodge Drive.
Timberwood
Hill.

EXCURSION TO CHARNWOOD FOREST.

WHITSUNTIDE, 1902.

SATURDAY, MAY 17TH, TO TUESDAY, MAY 20TH.

Directors: Prof. W. W. WATTS, M.A., Sec.G.S., C. FOX STRANGWAYS, F.G.S., and W. F. MARTIN.

Excursion Secretary: E. P. RIDLEY, F.G.S.

(*Report by* PROF. WATTS.)

THE excursion of the first day, *Saturday, May 17th*, was confined to the east and north-east of Charnwood Forest, because in this district the structure is simpler than elsewhere, the dip and the succession of the rocks is not much obscured, and the exposures are numerous and connected. The main disadvantage is that some of the more important "index-beds" are invisible, while others are not typical and do not show well the characters which have earned their names for them. Consequently there was at times a slight demur in receiving some of the statements of the Director on this day, although in the end a fair idea of the general succession of the main subdivisions was acquired.

By the kind permission of Mrs. Herrick the party was quite free to wander at will through the grounds of the Hanging Rocks and Beacon Hill, the beautiful annexe to Beaumanor Park. Work was begun in the Southern Slate Quarry, within sight of Woodhouse Eaves. Purple and green slates are exposed here, with Keuper Marl resting in a little valley scooped out of the edges of the slate. The dip, cleavage, contortion, and shearing of the slate were well seen, and also the scanty breccia of large angular fragments forming the base of the Marl. Just at the back of the quarry there is an exposure of the Brand Conglomerate with its pebbles of quartzite and slate, the lowest division of the Brand Series. It was pointed out that the strike of these two divisions did not conform to that of the other rocks in the Grounds, and that the next rock in *apparent* succession would be the great mass of the Hanging Rock itself, a coarse tuff with irregular and distorted bands of pale hornstone. Below this came the green hornstones, and, forming a base to so much of the Woodhouse Series as is here visible, came a second agglomerate in which hollow bombs and masses of slate were eventually found. This agglomerate displayed the usual pillar-like jointing, and it is correlated with the slate-agglomerate.

The party next ascended Beacon Hill, passing over an area of Trias and on to scattered occasional exposures of the typical fine-grained siliceous tuffs which the Director referred to as horn-stones. These are generally well banded in green, pink, and white colours, and show their succession clearly, although towards the summit of the hill the strike is much disturbed by one or two considerable faults which break across the country in both longitudinal and transverse directions. Some bands of epidote grit occur on the summit, and under a crag formed by one of them capped by pale cream-coloured contorted hornstones, the party took its well-earned rest and refreshment.

The carriages were resumed for a few yards, and the next halt was made at an unnamed wood north of Black Hill, where a large number of blocks of the Felsitic-Agglomerate were seen, probably not far from their natural position, and at the base of the Beacon Hill division of the Maplewell Series. The fact, noted by Hill and Bonney, that the clastic character of this rock is only visible on a fractured surface, was easily noted here for the first time. The next exposure visited was at Alderman's Haw, where a porphyritic andesite (porphyroid), which appears to be intrusive, is visible on about the horizon of the Felsitic-agglomerate. A little further, and the well-known Whittle Hill was reached, the quarry from which the Charley honestone is obtained. This rock is a very fine and even-grained tuff, hardened by the intrusion of a small dyke of syenite, and jointed so that it breaks into pieces convenient for the making of hones. Just above the rock of the quarry is a small crag of coarse tuff, which occupies the position, and has some of the characters of the Felsitic-agglomerate, whilst it is in line with exposures of a similar rock in Roe's Plantation, which there was not time to visit.

Lack of time also rendered it necessary to abandon the proposed visit to Morley Quarry, where there are hornstones and grits of the Blackbrook division, but the drive towards Newhurst gave the party its first example of one of the old longitudinal fiords now filled with Triassic Marl, through which small and large islands of the old rock, like that of Shortcliffe, here and there project. At Newhurst, recent quarrying operations have rendered very clear the relations of a great mass of syenite intrusive into the Blackbrook and Maplewell Rocks, probably along a line of fault which here separates the two series and repeats the succession. This fault is the eastern thrust-plane shown in the annexed diagrammatic section (Fig. 57), the south-eastern interior of which crosses the long section (Pl. XVII.) in the eastern flank o Beacon Hill and accounts for the large area occupied here by th Beacon Hill Hornstones. After getting specimens of the syenit which is here dark, basic, and very tough, so that it is capable resisting a high crushing stress, the party drove on to For Gate, beginning work again on the highest members of the r visible in that region.

In this old quarry slates and conglomerate, with a l ose grit (almost quartzite) are seen, but the best specimens › be seen are in the neighbouring walls. The "trachose grit" rmerly been also quarried in this neighbourhood, for many ents may still be seen lying about. On working down- from here the ›n Hill Horn- ; were again met at Buck Hill, he position of late-Agglomerate : Outwoods was :d out but not l.

ıe next halt was :ket Gate Farm, there the rock d many in- s; but the Direc- ıs unable to give information re- l. Instead, he d a small reward 'one who could him the dip, , position, com- on, age, or origin : rock; but the rd was not :d. As a matter :t, two or three udinal faults ap- to actually con- in the quarry, an important 'erse fault passes ı a few yards, so the rock is led out of all ıition. The preferred to from this point ›odhouse Eaves, were rewarded iting the Northern Slate Quarry, under the kindly guidance '. Humphries.

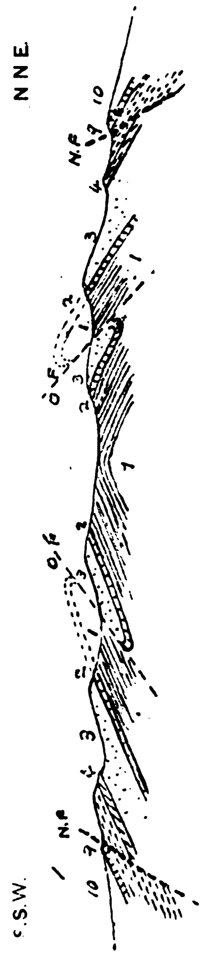


Fig. 57.—Generalised Section Across Charnwood Forest.—*By W. W. Watts.*

To Show the Structure and Faulting.

N.F.—Normal Faults. O.F.—Overthrust Faults.
10, Swithland Slates. 3, N.W. Agglomerates, etc.
9, Brand Conglomerate. 2, Felsitic agglomerate.
4, Slate-agglomerate. 1, Hornstones and Grits.

(See also index to Plate XVII.)

ıis rock succeeds the coarse tuff of the Hanging Rock in ır order, and if there is no faulting it must be on the horizon rocks of the Southern Slate Quarry. But it has no affinity with this, and is a coarse-grained slate with beautiful ripple-jointing, a feature observed generally throughout the Forest in the highest division of the Woodhouse Stage of the Maplewell Series. Hence it is concluded that a longitudinal fault runs along the eastern border of the main crags of the Hanging Rocks, separating them from those of the Southern Slate Quarry. The line of this fault passes through the west side of the Brand Grounds, as noted below. The circular markings which have been described as fossils were seen in this quarry. From Woodhouse the Association drove back to Quorn, and soon reached its comfortable quarters at Nottingham.

On *Monday, May 19th*, the drive from Quorn Station gave the party a very good view of the general appearance of the Forest. They toiled over the long hill of the Beacon, and then traversed one of the Trias-filled fiords to Charley Cross Roads, and on to the Oaks, noting on the journey the abrupt changes in the landscape wherever the streams or ablation had scooped out enough of the Marl to expose the Charnian Rock beneath. Some of these streams were longitudinal, and followed on the surface of the Trias the direction of fiords now filled with the Marl. But many of them turn out of the course of the old fiords at right angles, and escape from the Forest by passing transversely across the ribs which divided the fiords. So surely as this is done the landscape becomes immediately wilder and more rugged, the valleys are steeper and rockbound, and the vegetation changes. But immediately beyond the Oaks the Blackbrook stream, while still following the direction of the Triassic fiord, has cut down so deeply through the Marl that it has cleared the Trias completely out of it, and lays bare the only example of such a fiord in the region. Hence it is not surprising that this valley has characters of its own not elsewhere seen. Its abrupt sides, its rocky flanks and bed, and its meandering course, remind one of nothing so much as the "gutters" in the Longmynd. The foot of this fiord has been selected by the Loughborough Corporation for a reservoir, which is to occupy, on a larger scale, the site of the old reservoir of the Charnwood Forest Canal. Fortunately, Mr. Hobson, the engineer engaged in constructing the reservoir, was on the spot, and he gave to the Association a lucid and most interesting explanation of the site and its advantages, and pointed out the special difficulties which had been met with in the preparations for the lofty dam which is to convert so many of the middle reaches of the Blackbrook valley into a lake. The trench excavated for the masonry dam has given a new and unequalled section of the rocks of this part of the valley, and it shows the normal Blackbrook hornstones and thin grits, associated with a rock which is probably an intrusive porphyroid of a type similar to that of High Sharpley. The rocks of this section are about the lowest seen in the Charnwood anticline and the succeeding drive to the east ascended the sequence until the equivalent of the Felsitic-agglomerate was passed, and two or three exposures in the agglomerates which seem to be the western equivalent of the Beacon Hill Hornstones were visited. At Trilobate Plantation, after it had been pointed out, in answer to an inquiry, that trilobate was not synonymous with trilobite, specimens of a very fresh and brittle porphyroid were collected, and near Hob's Hole a coarse and massive agglomerate was well shown. The party drove through Whitwick until it arrived at High Sharpley, from which a grand view of the entire country opened out, tempered, however, with the gloom caused by the rapid approach of a heavy thunder shower. The rocks of the hill were well examined, and the curious knobby character and slaggy look due to the shearing of a nodular igneous rock was seen and explained, only just before the arrival of the storm compelled a hasty retreat into the fissures and caves of the rock, which were capacious enough to contain the whole party in comfort.

This storm heralded the break-up of the weather for the day, and it was a very wet party which stopped at the drive to Charnwood Lodge, or pushed on towards the smoky hospitality of the "Forest Rock." Those who faced the weather saw the magnificent exposure of massive, cleaved agglomerate exposed along the Drive, the sheared porphyroid near to Charnwood Forest Farm, the agglomerates and interbedded slate of Warren Hills, and above all these one of the exposures of a typical Slate-agglomerate, followed by hornstones like the Woodhouse Hornstones of the Hanging Rocks which had been visited on the preceding Saturday. These exposures of Slate-agglomerate serve to link the east and west sides of the anticline, and to make it almost certain that the main group of agglomerates, from Flat Hills and Timberwood Hill to Warren Hills and Abbots Oak are the equivalent of the Lower Maplewell Series of the east of the anticline, from the Felsitic-agglomerate to the Slate-agglomerate, inclusive.

It was found necessary to abandon the projected visit to Peldar Tor Quarry and Birch Hill, and the carriages drove direct to Bardon Hill, where, in the most difficult sections of the area, the rain rendered it practically impossible to make out the relations of the rocks. The intrusive junction of the porphyroid on the south flank of the quarries was not so plain as when the second stage was less cut back, while a new type of breccia was now exposed on the northern side by the quarrying away of a buttress in which rocks of "Slate-agglomerate type" had been formerly recognised by Bonney and Hill. It seemed to be the general opinion that this breccia was partly cataclastic in origin.

It was not found possible to visit the Trias junction or the new quarries in the higher part of the hill, although the whole area had been thrown open by the kindness of Messrs.

Ellis and Everard. Nor was it thought advisable to complete the rest of the day's programme; so the carriages were reluctantly turned homeward, and driven straight back to Loughborough.

On *Tuesday, May 20th*, the first halt was made at Woodhouse Eaves to study the exposure of purple-and-green-beds, conglomerate, little purple slate, quartzite, and "trachose grit" in the old quarry under the church.

The next halt was at the Brand, kindly thrown open by Mr. R. F. Martin, and here similar beds were again seen in the type locality for the Brand Series. Purple-and-green-beds, conglomerate, little slate, quartzite, trachose grit, and Swithland Slate all succeed one another in regular order, but a prolongation of the Hanging Rocks fault cuts off the purple-and-green-beds abruptly, and brings in the Slate-agglomerate to the westward after a very short interval. The very fine exposure of the Slate-agglomerate of Roecliffe was seen next, with the kind permission of Mrs. Heygate, and it gave for the first time a true idea of the characters of this remarkable rock, a coarse andesitic tuff, laden with small fragments of slate, and enclosing here and there large bent masses of similar slate.

The Countess of Stamford was good enough to allow the Association to traverse her woods in the neighbourhood of Bradgate Park and the Park itself, and full advantage was taken of this permission. Benscliffe Wood with its exposures of Felsitic-Agglomerate was first crossed, nearly along the line of the group of anticlinal faults which cause the frequent repetition of this band, in the wood itself and in a neighbouring plantation. In Hunt's Hill the Slate-agglomerate was found, nearly half-a-mile from its correct position, thrown back by a pair of faults, which account for the remarkable gap in the outcrop line of the Agglomerate at Old John Tower, and which bring on a slice of the ripple-jointed Olive Hornstones into this position. At the Tower Mr. Fox-Strangways gave an account of the Triassic and newer rocks of the immediate neighbourhood, calling attention to the features which could be observed from this admirable if windy point of view. The Slate-Agglomerate was again found in its normal position, after the fault had been crossed and recrossed, and then the party advanced over the half-mile or so of Olive Hornstones with their beautiful ripple-jointing, to reach the Quartzite and slates of Deer barn Wood and the Stable Pit, intruded upon by outlying dykes from the great mass of syenite which floors the south-western part of the Park. Unfortunately no worm tracks were found on this occasion in the slaty rocks.

After a short halt at Newtown Linford, the party pushed on to the Altar Stones at Markfield, one of the finest exposures of the Slate-agglomerate; they visited New Plantation with its splend[id] exposure of quartzite in contact with syenite; passed the old sla[te]

. AND SMOOTHED SURFACE OF GRANITE UNDER KEUPER MARL.

workings at Bradgate Farm, and drove on past the great syenite quarries of Groby to Leicester, where the excursion closed.

A small party, however, took advantage of a fine day to visit the Mountsorrel granite area. The old quarry of Buddon Wood, with its granite and its dykes, was first visited; next the great quarries of Mountsorrel itself were reached, and the rock, with its variations and dykes, was studied. Greater interest, however, was aroused by the junctions with the overlying Trias, and the evidences of supposed wind-erosion on the granite surfaces. At the entrance to the quarry lie the blocks derived from the first terraced surface found on removing the boulder-clay, which have been carefully preserved by Mr. Martin, and some of which he would be glad to see deposited and cared for in a museum. But in the quarry itself was a newly exposed surface of great beauty, only just being uncovered from its coating of undisturbed Keuper Marl. Several fine photographs were thereupon and afterwards taken of this—the finest exposure which has yet been seen of terraced granite under Keuper Marl. By the kindness of Prof. H. E. Armstrong, we are enabled to reproduce one of these photographs (Plate XVIII), which shows the terraced and grooved granite to the right of the shovel, and the bedded Keuper Marl to the left of it. Although no doubt existed in the Director's mind before, this exposure rendered it absolutely certain that the *smoothing and terracing* of the granite first originated *during* or *before* the deposition of the Keuper Marl. Other examples of smoothed and terraced surfaces were seen at Hawcliffe, and a little search at this spot yielded several specimens of glazed and ribbed fragments with wind-polish on them. The railway cutting out of Nunckley Hill Quarry still displayed a previously described terraced surface of granite in contact with a thin skin of Marl, both covered directly with a boulder-clay in which were abundant glaciated fragments of hard chalk. The next point visited was the reservoir of Buddon Wood, kindly opened for the Association by the Corporation of Leicester. The gardens, machinery, filter beds, and methods of sand washing were exhibited, and excited much interest. The day's work closed with a walk to Brazil Wood, where the old quarry with its granite dykes and highly altered slates now converted into hornfels was seen.

To summarise, the general plan of the Excursion was to display the succession of the Charnian rocks and the rock-structure of the Forest, and to give the evidence from which this structure—an anticline traversed by thrust-planes and drop faults, both longitudinal, and crossed by transverse faults—had been made out. The keys to the position are :—(1) the Felsitic-agglomerate (2) the Slate-agglomerate, (3) the Brand Conglomerate and its associated beds of quartzite, "trachose grit," and slate. The last-named member was traced round the Forest from Forest

Gate, through Hanging Rocks, Woodhouse, the Brand, and Deer Barn Wood, to New Plantation. The Slate-agglomerate in the Outwoods was not visited, but south of this point it was traced through Hanging Rocks, the Brand, Roecliffe, Bradgate Park, Altar Stones (and possibly Bardon Hill) to Warren Hills at the back of Forest Rock. The Felsitic-agglomerate was picked up at Whittle Hill and then traced through the plantation near Black Hill, to Benscliffe. In the north-west of the area it becomes merged into the massive Agglomerates of Flat Hill, Warren Hill (N.), and Charnwood Lodge. Inside the lowest of these three divisions come the Blackbrook Rocks; outside them the Swithland Slates; between them the two divisions of the Maplewell Series, the Beacon Hill Hornstones and the Woodhouse Beds respectively.

The map which accompanies this report is a first attempt to portray the rock-structure of Charnwood Forest as it would appear if the Trias and more recent rocks were stripped off. While theoretical at many points, it is thought by the Director that it gives an approximate explanation of the facts observed in the field, while the faults inserted are the simplest series he has been able to think out to explain the facts known to him. Most of these facts were collected while he was surveying the geology of the district as a member of H.M. Geological Survey, but a considerable amount of field and office work has been carried out since that time in the area.

In closing this account, the Directors wish to express their very hearty thanks to those ladies and gentlemen who helped to make the Excursion successful: The Countess of Stamford, Mrs. Herrick, and Mrs. Heygate; Mr. R. F. Martin, Mr. W. F. Martin, Mr. Edwin de Lisle, Mr. H. A. Payne, Captain Heygate, Messrs. Ellis and Everard, Messrs. G. and F. W. Hodson, the manager of the Whitwick Granite Quarries, the members of the Leicester Literary and Philosophical Society, and the Leicester Corporation. The Directors are also glad to take this opportunity of giving their especial thanks to Mr. Coke; and to Mr. E. P. Ridley, to whose care and businesslike management as Excursion Secretary the comfort and smoothness of all arrangements were due.

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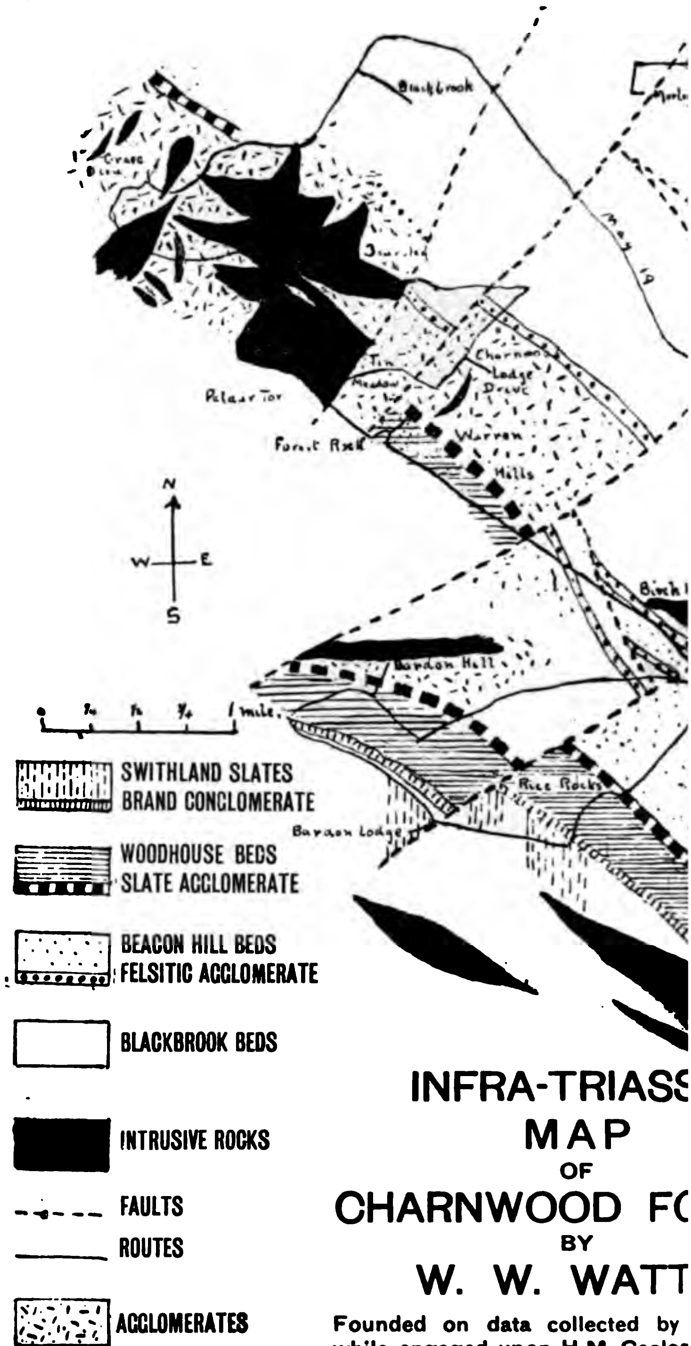
Blackbrook
Peldar Tor
Forest Rock
Warren
Hills
Bardon Hill
Rice Rocks
Bardon Lodge
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W
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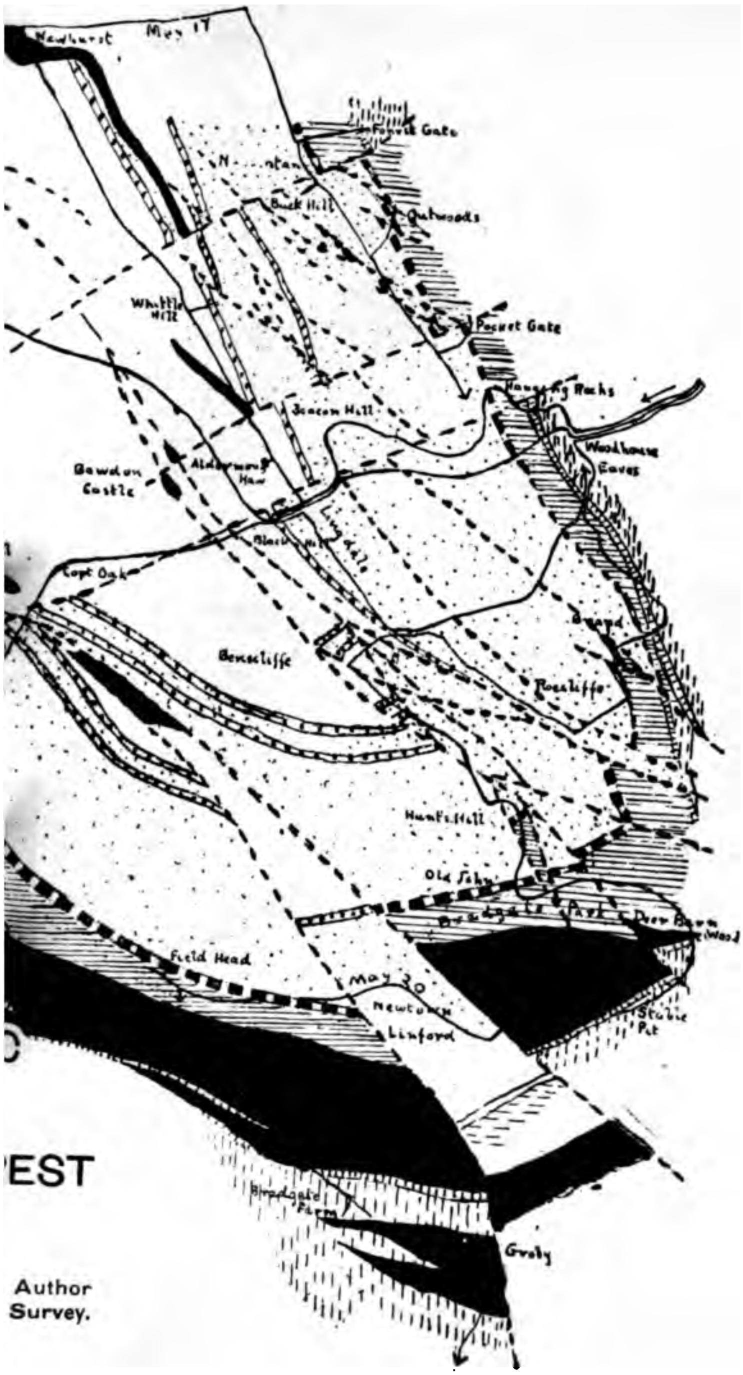
1 mile.
SWITHLAND SLATES
BRAND CONGLOMERATE
WOODHOUSE BEDS
SLATE AGGLOMERATE
BEACON HILL BEDS
FELSITIC AGGLOMERATE
BLACKBROOK BEDS
INTRUSIVE ROCKS
FAULTS
ROUTES
AGGLOMERATES
INFRA-TRIASS
MAP
OF
CHARNWOOD F
BY
W. W. WATT
Founded on data collected by
while engaged upon H.M. Geolog


Newhurst
May 17
Forest Gate
Buck Hill
Outwoods
Whittle Hill
Pocket Gate
Hanging Rocks
Beacon Hill
Woodhouse Eaves
Bawdon Castle
Aldermans Haw
Black Hill
Lingdale
Copt Oak
Benscliffe
Roecliffe
Hunts Hill
Old John
Bradgate Park
Deer Barn Wood
Field Head
May 20
Newtown Linford
Stable Pit
EST
Bradgate Farm
Groby
Author
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EXCURSION TO READING.

SATURDAY, MAY 31ST, 1902.

Directors: O. A. SHRUBSOLE, F.G.S., and W. WHITAKER, B.A., F.R.S.

Excursion Secretary: A. K. COOMÁRASWÁMY, B.Sc., F.G.S.

(*Report by* THE DIRECTORS).

E party on arriving at Reading proceeded to inspect a section :he Valley Gravel which is exposed in Kensington Road near the u nty Cricket Ground. There is about 20 feet in depth of gravel wn here forming part of a terrace left at a late stage of valley-sion, since the surface is only 22 feet above the river Thames the nearest point, which however is fully half-a-mile distant. e gravel is evenly bedded with sandy and chalky seams. It tains pebbles of chalk and many large fragments of black flint icating the waste of the Upper Chalk at no great distance. A pebbles from the Bunter conglomerate are found and also mmalian bones, generally too imperfect for determination, but ently canines of *Hippopotamus major* have been found. The vel is generally destitute of traces of man, the finding of an plement being of rare occurrence, and in that case it might 'e been derived from an older gravel.

Thus it would seem as if man was not in the vicinity of the ames at this time, and this stage might represent the supposed ak between Paleolithic and Neolithic times in this country. w far the migration of man and possibly of other Mammalia ht be a result of excessive humidity of climate was a matter speculation. It is at least worthy of note that hippopotamus occurred here and not at the higher levels. Mr. Whitaker nted out the calcareous nature of the gravel as an indication of comparatively late date and drew attention to the pipes that e already in course of formation at the surface of the gravel chemical agency.

A few minutes' walk brought the party to a section in the Tilehurst Road, showing about 12 feet of gravel overlying the upper part of the Woolwich and Reading beds. This is at a much higher level, the surface being 75 feet above the river Thames, and the spread of gravel is continuous over the parting between the Thames and the Kennet. Mr. Whitaker pointed out the way in which the valley had been excavated at this point, both the Tertiary beds and the older terrace having been cut into. It was a good illustration of terrace-formation. Mr. Shrubsole said that the gravel here had furnished a fair number of flint implements. It was also noteworthy for the number of flakes and slightly worked flints that occurred. A number of flakes were found without difficulty by members of the party. The gravel here is generally of a deep ochreous colour, but patches of a lighter colour occur, which seem to be due to the irregular action of the process of decalcification, etc. This pit has also yielded mammalian bones—horse, ox, and mammoth being the most common. A molar of rhinoceros has also been found. This pit has sometimes been referred to as the "Grovelands" pit.

Proceeding in a westerly direction past brickyards in the Woolwich and Reading beds, which there was not time to explore, the party reached the Norcot brickyard. Here Mr. Whitaker pointed out the basement-bed of the London Clay overlying the Reading Series. From this horizon a few imperfect fossils were obtained. The top of the hill, which commands a fine view of the Thames Valley, also exhibited in the gravel an earlier stage in its history. It is here 172 ft. above the level of the Thames at the nearest point, and thus nearly 100 ft. higher than the Tilehurst Road gravel. The distinctive feature of the gravel is the high percentage of Triassic pebbles which it contains, along with occasional fragments of igneous rock, rolled and unrolled, such as devitrified rhyolite, etc. This has been called Plateau Gravel by the Survey. It ranges over a considerable area on both sides of the river. Mr. Monckton referring to his paper on the subject* said that three distinct types of gravel were noteworthy in this district: 1, The gravel containing purple quartzites; 2, That containing chert fragments; 3, That from which both these were absent.

Returning to Reading a visit was made to the Waterloo kilns near Katesgrove. Here a somewhat similar section to that at Norcot was observed, but the gravel was of a later date. This section was visited especially for the "leaf-beds" which occur in the lower sands of the Woolwich and Reading Series, in seams of a sticky loam intercalated in the sand. Mr. Monckton alluded to the interest of this indication of a land-surface with luxuriant vegetation immediately overlying deposits proved by its fossils to be of marine or estuarine character. Thanks to the assistance of two stalwart workmen, a good quantity of the leaf-bearing soil

* *Quart. Journ. Geol. Soc.* vol. xlix, p. 308.

was got out, and numerous examples of the leaf-impressions were secured.

This section has been referred to by J. Starkie Gardner,* who notes the occurrence of *Taxodium Europæum*, *Platanus*, *Onoclea*, *Pteris*, *Osmunda*, etc., here and at other places, the whole having a remarkably temperate aspect. These forms were afterwards driven northwards by warmer conditions in the time of the London Clay. Mr. Whitaker also remarked generally on the section. Some fossils were afterwards obtained from an adjacent pit now worked out.

After tea at the Abbey Café, the Abbey ruins and the museum were visited, and the party returned to London.

The heights of the sections of gravel visited are as follows:—

	Above river.	Above sea-level.
Kensington Road	22 ft.	144 ft.
Tilehurst Road	75 ft.	197 ft.
Norcot	172 ft.	294 ft.

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EXCURSION TO HEADINGLEY, SHOTOVER, AND WHEATLEY.

JUNE 7TH, 1902.

Director: REV. J. F. BLAKE, M.A., F.G.S.

Excursion Secretary: A. C. YOUNG, F.C.S.

(*Report by* THE DIRECTOR).

THE excursion commenced at the tram terminus, on the Cowley Road from Oxford. This lies on a nearly level surface of Oxford clay. Taking the footpath that leads thence towards Headingley, a low feature over which the path rises marks the commencement of the Lower Calcareous Grit, and the soil thereafter becomes sandy. After reaching the high road, a recently made excavation was found on the left hand side, which showed some 10 ft. or so of the grit, and it was found to contain here some inpersistent bands of calcareous stone of a rough character, without observable fossils, and these it was stated are found for

* *Quart. Journ. Geol. Soc.* *Palæont. Soc.* "Eocene Plants."

some distance down. As such bands are seldom seen in natural exposures of the sand, it is to be supposed that in such situations they have been dissolved out (see Phillips' Geology of Oxford, p. 299). The gradual rise to the base of the Coral Rag does not indicate any great thickness here, probably not more than 60 ft. The first quarry of limestone visited was the well-known Windmill quarry, showing the Calcareous Grit with doggers at the base and the variable Coral Rag, with very little solid material between it and the Grit. Its dip towards the hill was noticed, and its *Thecosmilian* character, but the approach of a thunderstorm drove the members to seek shelter.

The next quarry visited was a deep one, nearly opposite the vicarage. The lower part is composed of rough Coral Rag, as in the last quarry, with fragments of the outer whorl of *Am. varicostatus*, but the upper half consists of massive shell débris, obviously the washings of material like the lower half.

At the corner of the road to Shotover, the next succeeding stage was seen, where this same massive rock was being quarried in an 8 or 10 ft. face, and overlaid by a few feet of dark blue Kimeridge Clay. The junction of this with the light grey stone makes an admirable contrast, and is seen to be highly irregular as though by weathering. So sharp is the junction that it suggests at first sight that the clay has slipped forward; but this possibility is negatived by the occurrence of undisturbed hard bands in the clay. Nests of *Bel. explanatus* were here observed in the Kimeridgian.

From this quarry the ascent becomes rapid, and the next opening, or brickyard, shows Kimeridge Clay at the base, apparently on a higher horizon than that previously seen, the nodules containing a *Perisphinctes* allied to *P. thurmanni.* Just above the level of these the sandy matrix of the Lower Portlandian commences, and gradually becomes a more massive stone, in which *P. pectinatus* was found by Phillips and by later collectors. It is not easy to distinguish on this hill any line of junction between the Portlandian sand and the overlying Shotover freshwater sands, but the former are more argillaceous, and the latter more ferruginous. It is, however, known that the upper deposit must be unconformable, because the true Portland Limestone, with *Trigonia gibbosa*, occurs about two miles away at Garsington and Cuddesdon. There was no time, however, to visit these localities.

The Shotover Sands form a kind of plateau from which a fine view is obtained, but which affords no exposures. The next pit visited was therefore the brickyard near Wheatley, south of the railway, where was seen the same Kimeridge Clay with Ammonites as before, but nothing higher. At the same level on the north side of the railway occurs the Corallian Limestone, so that the fault on the Survey map must indicate a throw of about 100 ft.

After tea at Wheatley, three quarries of the Corallian Limestone were examined—one at the west end of the village, one just behind it at the junction of two roads*, and a third at some distance away at the turning to Stanton St. John. All the deposits in these quarries are of like character, consisting of a series of bands of fine shell brash, scarcely to be called an oolite, alternating with thicker beds of the same material compacted into building stone of uniform character. This is no more than a greater expansion—some 30 ft. probably—of the material seen overlying the Rag at the Headington quarries. No corals are seen here, but the ordinary molluscan fauna of Corallian species is not uncommon. The idea presented is that Headington was the centre of the coral growth, and from thence the débris of it has been spread out on all sides.

The loss of time at Headington, owing to the storm, necessitated, for the carrying out of the programme, a sharp walk back to Oxford.

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EXCURSION TO THE VALLEY OF THE MOLE, BROCKHAM, REIGATE AND REDHILL.

JUNE 14TH, 1902.

Directors: W. P. D. STEBBING, F.G.S., and WILLIAM WHITAKER B.A., F.R.S.

Excursion Secretary: E. W. SKEATS, D.Sc., F.G.S.

(*Report by* W. P. D. STEBBING.)

CONSIDERING the weather at the beginning of the day a fair sized party essayed this walk between two of the valleys that cut the escarpment of the N. Downs.

Starting from Dorking Station (L.B. & S.C.R.) the party first walked up to Burford Bridge, where, in the grounds of Fredley one of the swallow-holes for which the Mole is famous was inspected by the kind permission of Mrs. Kay and Miss Drummond. This hole, which only works when the river is fairly high, was now

*In this quarry is an interesting relic of rougher times in a walled chamber with a pyramidal roof, which was formerly used as a kind of pound to lock up drunken men in.

so full owing to the wet weather, that it was not seen under the best conditions. The entrance is at right angles to the flow of the stream, and the holes, which come into action according to the height of the stream, run in a line parallel to and up the stream. The action of swallow-holes and their history were explained by the Directors, and Mrs. Kay's gardener pointed out the features of this one. In the grounds of Fredley and Burford Lodge, which was next visited by kind permission of Sir Trevor Lawrence, several depressions were pointed out by the Directors which are connected underground with the Mole so that water rises in them when the stream is high, and which act as swallow-holes when the river floods the low ground. Water was seen in one of these. On entering the grounds of Burford Lodge the party walked along the banks of the Mole which here runs immediately beneath the steep scarp of Box Hill. There are here several small swallow-holes in the bed of the stream, but they are only to be seen when the water is low. Emerging on to Box Hill through a private gate, the party made its way to a point where the view was unobstructed. and where Mr. Whitaker pointed out the physical geology of the district.

Thence the party continued by road to the Brockham Brick and Lime Company's quarries and pits, where, first, a section showing the false-bedded sands of the Folkestone Beds with iron concretions was seen, then a section in the Upper Gault without fossils, and then an interesting section in the higher beds of the Upper Greensand covered with about 8 feet of chalky hill-wash containing land shells of several species. This extensive bed, as was pointed out by Mr. Whitaker, was of rather exceptional interest, marking, as it did, the subsoil formations, proving its approximate age from the included land-shells, and, thirdly, its rate of deposition, which seemed to show a heavier rainfall than at present, with intermittent periods of rest, as was shown by a dark band of vegetable matter at a certain height in the bed.

The junction of the Upper Greensand and Chalk Marl could not be seen, but in the quarry just above a fine section of Lower and Middle Chalk, each showing the characteristic bedding and jointing, was seen, with the zone of *Belemnitella plena* and Melbourne Rock at the junction. From this point the party walked along a fragment of the Pilgrims' Way to the Betchworth chalk quarries and took a muddy path across fields to Buckland. Here taking another path S. of the village the party made their way on to Reigate Heath, where a short halt was made at a small section in the sand of the Hythe Beds. Continuing the walk past the pumping station of the East Surrey Water Works, the road at the N.W. corner of Reigate Park was reached, and there a fine cutting was seen in the Hythe Beds in which Miss Crosfield has found remanié fossils. The ridge above Reigate Park being traversed at the E. end there was a stop to admire the views N.

and S. and to hear some remarks made by Mr. Whitaker on the physical features of the country seen from this magnificent outlook.

The party then walked to Earlswood Common, on the north side of which Mr. John Brown's brickfield in the Atherfield Clay was visited. This interesting section of a Lower Greensand division that is very rarely seen, shows a lower part of blue sandy clay and an upper part of yellow and buff clays, the total height of section being about 15 feet. The lower bed contains many large nodules of different degrees of hardness, yielding a rich fauna, which seems to have lived *in situ* as the President found a perfect specimen of *Gervillia aliformis* with both valves united. The following is a list of some of the species found :—

Nautilus radiatus,
Gasteropods (several species),
Corbula striatula,
Exogyra sinuata,
Gervillia aliformis,
Ostrea sp.,
Panopea sp.
Pecten interstriatus,
Perna mulleti,
Pinna sulcifera,
Trigonia sp.,
Terebratula sella,
Holocystis elegans.

From this section, which had to be left all too soon, the party passing by a sand-pit on Red Hill showing the characteristic red sands, and walking through Red Hill, reached the hotel near the station, where a much needed tea awaited them. Afterwards the President moved a vote of thanks to the Directors, which was replied to by Mr. Stebbing.

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EXCURSION TO KINTBURY, INKPEN, and WOODHAY.

SATURDAY, JUNE 21ST, 1902.

Director: H. J. OSBORNE WHITE, F.G.S.

Excursion Secretary: E. W. SKEATS, D.Sc., F.G.S.

(*Report by* THE DIRECTOR.)

ON arriving at Kintbury, about 11.30 a.m., the members were met by Mr. S. B. Dixon, of Pewsey, who had kindly brought a large selection of palæolithic implements from the valley-gravel of Knowle, near Savernake, for their inspection. Converting the station waiting-room into an extemporary museum, Mr. Dixon gave a short account of the mode of occurrence of the deposit from which these, and many hundreds of similar implements, had recently been obtained, and illustrated his remarks with the six-inch map of the district. The implements shown were, on the whole, of inferior workmanship, and were likened by Mr. Ll. Treacher to those found around West Drayton and Iver, in Middlesex. Many exhibited a peculiarly bright, varnish-like glaze, difficult to explain, and clearly not attributable to wind action, since it was unaccompanied by any appreciable rounding of the finer edges between the grooves from which flakes had been struck in the process of manufacture.

Walking southwards from the village, the party soon reached the Chalk platform, with its dome-shaped Eocene outliers, overlooking the Kennet. The first section examined was in the higher part of the Upper Chalk, exposed in a pit about 20 feet in depth, on the west side of the road to Pebble Hill. The Chalk here was soft and white, on the whole, but contained a hard cream-coloured "rock" band near the top, which rendered the southward dip of the beds very perceptible. The Director drew attention to the almost complete absence of flints from the upper 15 feet of the section, and remarked that their scarcity suggested that this Chalk belonged to a somewhat higher stratigraphical horizon than did that occurring immediately below the Tertiaries in the Reading district (*i e., Micraster cor-anguinum*), in which flints were abundant.

Search was then made for fossils, and the few obtained were subsequently sent, for identification, to Mr. Jukes-Browne, who has kindly furnished the following list:—

Actinocamax granulatus ? (part of the alveolar end).
Spondylus sp. (? S. spinosus).
Echinocorys vulgaris (Leslie), rather small.
Porosphæra globularis.
Ventriculites quincuncialis.
Tooth of a small fish.

With regard to the first-named fossil, Mr. Jukes-Browne rites :—"The alveolus is rather deep and resembles those from ıe *Act. quadratus* zone more than those from the Margate halk"; and, further, that this specimen "shows that if the ıalk does not belong to the zone of *Marsupites* it must be near ıe top of the *Cor-anguinum* zone."

The next item on the programme was a visit to Mr. Killick's rickyard, on the northern slope of Pebble Hill. The principal ection in the pits there is figured in the "Geology of the London asin," p. 183. The heavy rains in the earlier part of the year ad led to so much slipping that few details could be made out n the present occasion. The Director was able, however, to oint out the position of the junction of the Reading Beds and ıe London Clay. Some masses of brown clay-ironstone, and a w exceptionally large flint pebbles (one measuring roughly 2 × 6 × 6 inches), from the basement bed of the London Clay, ere noticed on the floor of the pit. Shallow workings lower own the hillside showed the characteristic mottled clay of the eading Series. It was remarked that the London Clay, which ttained a thickness of between 400 and 500 feet near London, ad here thinned out to about 50 feet., while the Reading eds retained their customary thickness of about 60 to 70 eet; but that near Bedwyn, some seven miles farther westward, ıe total thickness of the two formations was reduced, according ɔ Mr. Whitaker, to about 30 feet, the higher being represented y its basement bed alone.

The bed of shingle forming the plateau-like summit of Pebble Iill next claimed attention. This deposit, which is from 10 to 5 ft. in thickness, occurs near the base of the Lower Bagshot eds, and is separated from the London Clay by a thin bed of ınd. Its former extension northward cannot be determined, ɔr no relic of Lower Bagshots has been preserved in that direcon, but it thins out rapidly to the east, south, and west. The ccurrence of such apparently-isolated banks of pebbles in the ıidst of fine clays and sands evidently laid down at some istance from the shore-line, is probably attributable to the ıdden checking, or dissipation, of strong off-shore currents, on ncountering opposing currents, or on entering deeper water. ike the very similar, but less extensive, pebble-bed in the eading Series of the Lane End outlier, in South Bucks, this ıass of shingle was formerly regarded by the officers of the eological Survey as a drift gravel, but the complete absence of ngular flints and of sarsen-stones, which abound in the neighouring drifts, both at higher and lower levels, serves to istinguish it from these last. Mr. Whitaker observed that the ıistake, in this case, was a pardonable one, for at the time when ıis district was first mapped geologically the drifts had been

little studied, and such things as Lower Bagshot pebble-beds were almost unheard-of.

Continuing their walk southwards, by Kintbury Crossways, the party crossed the longitudinal axis of the London Basin, and commenced the ascent of the short dip-slope on the southern side of the syncline. In the pits at the north-eastern corner of Inkpen Common the following section was seen :—

		Feet.
	4. Brown, loamy soil and subsoil, with angular flints, pocketed into underlying beds :	1 to 2
DRIFT.	3. Stiff, greyish and brown sandy clay ; filled with white, angular flints (1 to 2 ins. diam.) and a few flint pebbles ; possessing a roughly stratified or banded appearance —the layers being frequently contorted ; and including "eyes" or lenticles of gravel. In the lower part of this bed two, partly rounded, blocks of hard, greyish, sarsen-stone, with numerous rootlet groves. The larger of these measured about 2 × 1 ft. at exposed end. Other specimens from this bed lay on floor of pit :	2 to 4
	2. Irregular and impersistent layers of brown loam and sand, with inclusions of stony clay and gravel ; passing down into bed below :	0 to 3
LOWER BAGSHOT BEDS.	1. Fine, yellow, greyish, and brown, current-bedded sands, with an undulate layer, 1 to 3 ins. in thickness, of black sand or sandstone, throwing out water, near the top: shown	10

The Director expressed the opinion that the bedding or banding noticeable in beds 2 and 3 was a flow-structure, incidental to a former "creep" down the gentle northward slope, and that the deposit itself, though now almost as tough and well-compacted as the Chalky Boulder Clay of the Eastern Counties (which, in its more contorted parts, it somewhat resembled), had once been a pasty "sludge," not improbably formed under glacial conditions. The low position of the sarsens in the drift, and the sagging-down of the bands of stony clay and loam in their vicinity, pointed to their having settled down after the forward movement had ceased.

After a short rest for luncheon the members resumed their walk, by Kirby House, near the source of the Enborne, and across the narrow edges of the upturned Eocene beds, noticing the changes in the character of the soil and vegetation on the sides of the road-cutting as they passed from these beds on to the Chalk. The Director pointed out the position of the interesting well-sinking which had proved the hitherto unsuspected presence of Lower Bagshot Beds, in considerable force, close to the Chalk outcrop. Details of this well-section will be found in Messrs. Blake and Whitaker's "Water Supply of Berkshire," p. 52, but the thicknesses of the principal sub-divisions of the Eocene rocks traversed may be mentioned here. These were:

	feet.
Lower Bagshot Beds	90
London Clay	52
Reading Beds	75

As the beds dip northward at 26°, their true thicknesses are about $\frac{8}{9}$ of the above, *e.g.*, London Clay 46 ft.

Traversing the outcrops of the Chalk and Melbourn Rocks (hidden by a sheet of flinty loam), and the axis of the Pewsey-Kingsclere anticline in rapid succession, the party reached the foot of the bold Chalk escarpment of the Sydmonton Hills, which forms the northern limit of the Hampshire Basin. Here the road forks, the eastern branch winding up the face of the scarp above West Woodhay, the western leading, literally, "to the gallows," since it passes under the gibbet which stands on the crest of the downs above Inkpen, and forms a conspicuous landmark for many miles around. Taking the former branch, the members gained the summit a little to the south-east of the large British earthwork known as Walbury, and paused to admire the fine view of the western end of the London Basin. From this point of vantage the Director indicated the chief objects of interest in the landscape, and gave some account of the more important geological and physiographical features of the district.

Attention was first directed to the contrasts afforded by the broad dip-slope of the Chalk of the Berkshire and Marlborough Downs, rising steadily to the north and north-westward, and culminating in the heights of Uffington and Liddington Castles and Hackpen Hill, which formed the background of the view; the wooded Tertiary country of the Vale of Kennet, in the middle distance; and the strip of open fields in the foreground marking the uprise of the Chalk at the southern margin of the basin. Turning next to the important anticline on whose southern limb the members were standing, the Director stated that the fold commenced, as a gentle swell, near Odiham, in the north-east corner of Hampshire, and ran with varying but generally increasing strength, for a distance of fifty or sixty miles, in a direction somewhat north of west, to beyond Devizes, in Wiltshire. Its form was arcuate in plan, with a northward convexity, indicating a thrust from the south. As in all the larger anticlines affecting Upper Cretaceous and later rocks in the south-east of England, its northern limb has a much higher dip (from 10° to 35° in this district) than its southern (2° to 4°). The fold actually consisted of a succession of closely connected, elongate, periclinal domes. In three of these periclines—viz., those marked by the longitudinal "elevation" valleys of Kingsclere, Shalbourne and Pewsey—the Upper Greensand had been brought within reach of the subaërial agencies of erosion, but in the rest the base of the Chalk had not

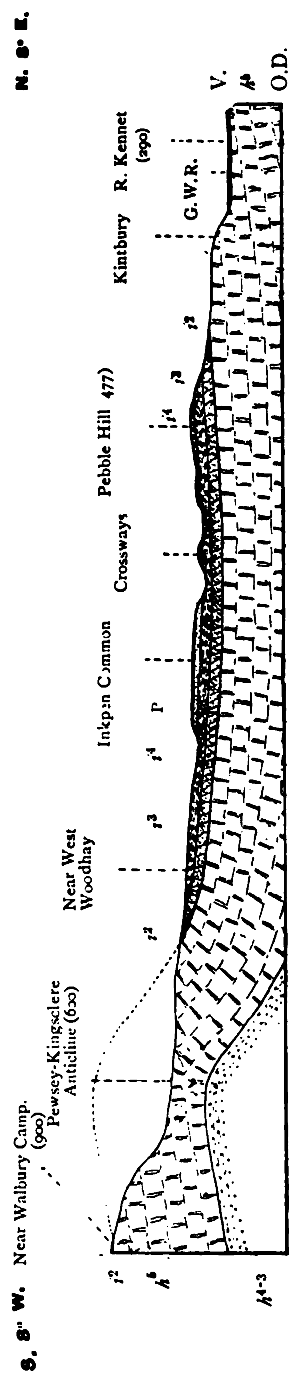

FIG. 58.—DIAGRAM SECTION FROM THE SYDMONTON HILLS TO KINTBURY.—*H. J. Osborne White.*

Distance 4 miles.

V. Alluvium.
P. Flint gravel with sarsens.
i^4 Lower Bagshot Beds.
i^3 London Clay.
i^2 Reading Beds.
h^5 Chalk.
h^{4-3} Selbornian, and older rocks.

Vertical scale much exaggerated. The figures in brackets show heights in feet above O.D.

yet been exposed. With regard to the age of this anticline, it was remarked that such evidence as existed went to show that no important movements had taken place along this line of weakness during early Tertiary times. The outlier of mottled clay hard by on the crest of the escarpment, at the extreme northern edge of the Hampshire Basin, showed that the shallow-water deposits of the Reading epoch had extended across the site of the existing arch, while the Lower and Middle Eocene beds in the adjoining part of the London Basin, a few hundred yards to the north, appeared to be a conformable succession affected equally by the disturbances to which that arch was due. The fold was probably an outcome of the Mio-Pliocene movements mainly responsible for the larger, and more complex, anticline of the Weald.

With reference to the physiography of the district, the Director observed that the relatively insignificant feature made by the Chalk on the northern limb of the above-mentioned anticline to the east of Inkpen was largely attributable to the high dip, which not only narrowed the outcrop, but also lessened the stability of the rock. A few miles westward, where the dip decreased, the Chalk on the northern side of the fold rose into a line of heights which dominated those on the southern.

The drainage was very simple and systematic. The formation of the east-west anticline had originally given rise to a number of streams running northward and southward from the crown of the arch to, the Kennet-Thames, or the Frome-Solent, and, broadly speaking, this primitive arrangement still held good. In the immediate neighbourhood of the anticlinal axis, however, the drainage had undergone significant modification, and, save in a small area near Burbage, the water-parting no longer coincided with this axis. To the east of the village named, the northward streams had had things much their own way; removing the crown of the arch; developing small longitudinal branches along the axis of the fold; and pushing back the heads of the competing southward streams, now represented only by gaps in the southern Chalk escarpment. But to the west, the conditions were reversed, and the southward-flowing Salisbury Avon had gained the upper hand.

Dealing, in conclusion, with the origin of the broader features of the wide expanse of country in sight, the Director referred to the views of Topley, Davis, and other writers, who had seen, in the summits of the Chalk uplands, the remnants of an uplifted plain of erosion, out of which they had supposed the existing diversity of hill and vale to have been carved; and pointed out certain difficulties in the way of this hypothesis, such, for example, as that of finding a sufficient thickness of late Tertiary rocks to fill the topographical depressions of the London and Hampshire Basins. He believed these depressions to be largely of constructional origin, and doubted whether the south-east of

England had been subjected to such widespread planation as those writers had inferred since the completion of the folds affecting the rocks of that region. There were, however, indications of lengthy pauses in the down-cutting of the valleys, and the most important of these in the district under observation, was that marked by the extensive gravel-plateaux and terraces, on either side of the Kennet, belonging to what the speaker had recently termed the "Silchester Stage." The moderate, partly drift-built, slope northward from the foot of the Sydmonton Hills (well shown on Inkpen Common) appeared to have been graded with reference to the position of the local base-level of erosion during that stage, and it was now being gradually destroyed by the widening of the small valleys by which it was dissected.

A pleasant walk along the grassy crest of the upland brought the party to Pilot Hill, where they descended to the large chalk-pit above Stargrove. A short distance to the north-west of this spot, the axis of the anticline, which elsewhere follows the foot of the Chalk escarpment, runs obliquely into the face of the downs. The beds exposed in this pit consequently dip outwards instead of inwards, facilitating quarrying operations to a dangerous degree. The Director commented on this unusual coincidence of an "escarpment" with a dip-slope. The Middle Chalk shown here had the usual massive character, save near the eastern end of the section, where there were abundant signs of crushing and faulting. A ferruginous cast of a sponge, somewhat resembling the Lower Chalk form *Plocoscyphia mœandrina*, was the only fossil found which is worthy of note.

The route now lay north-eastward, by a green road and a pretty hollow lane, bordered with *Scolopendrium* and other ferns, to the Hollington Brickworks, where some time was spent in examining the following comprehensive section of the local Eocene Beds.

		Ft.	In.
DRIFT	White, angular flints, and flint pebbles in stiff, unstratified, mottled reddish-brown and greyish sandy clay ...	1 to 8	0
LOWER BAGSHOT BEDS.	(20). Laminated, grey, iron-shot sandy clays ... ... shown	8	0
	(19). Yellow sand, with black markings, and hollow ironstone concretions	3	0
	(18). Grey, iron-stained, clayey sand	1	6
	(17). Yellow sand	0	6
	(16). Grey, iron-stained, pipe-clay	0	10
	(15). Brown and yellow sand, with black markings	2	0
	(14). Obscurely laminated and banded, brown and greyish sandy clay	20	0
	(13). Layer of flint pebbles	0	2
	(12). Alternations of yellow sand and brown clay, with a pebbly layer near middle	8	0
	(11). Fine yellow sands ... ... shown	5	0

Section obscured.

			Ft.	In.
LONDON CLAY.	(10).	Yellow sandy clay in rabbit burrows	25 (?)	0
	(9).	Greyish, brown-mottled clay, with masses of clay ironstone and of grey concretionery marl	25	0
	(8).	Seam of very small black and white flint pebbles		
	(7).	Grey sandy clay, marly towards top	2	6
READING BEDS.	(6).	Dark grey, or black clay	2	0
	(5).	Dark grey sandy clays	15	0
	(4).	Dull red and yellow mottled clay, becoming grey at top ...	5	0
	(3).	Grey sands	6	0
	(2).	Yellow and grey sandy clay	10	0
	(1).	Red and yellow sands		
		Base not shown.		

The measurements given above are only approximate.

The Eocenes in this section possessed a strong north-eastward dip, amounting to about 30° in the Bagshots and London Clay, but distinctly less in the lower part of the Reading Series. The change in inclination, which was most noticeable in that part of the section occupied by beds 3 to 4, was evidently due to a minor undulation in the larger fold.

The thick bed of clay, numbered (14), is probably the Ramsdell Clay.

The junction of the lower Bagshot Beds with the London Clay was hidden. That of the latter with the Reading Beds the Director was disposed to place, provisionally, at the seam of pebbles (8); but Mr. Whitaker, while admitting the difficulty of drawing a hard and fast line of demarcation between the two divisions in such a section, was inclined to place the bottom of the London Clay a few inches below that horizon.

The stony clay dift covering the edges of the Bagshot Beds thickened rapidly north-eastwards with the slope of the ground, as though it had filled up some pre-existing hollow.

Having partaken of tea, and passed a vote of thanks to the Director, at the Axe and Compasses, in the neighbouring village of East End, the members made their way to the pit in the low-level, flint and sarsen gravel of the Enborne, a little to the west of Woodhay Station, where they spent the few minutes that remained before the departure of the 6.46 p.m. train to London.

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EXCURSION TO AYOT AND WELWYN.

JULY 5TH, 1902.

Directors: JOHN HOPKINSON, F.G.S., A. INST. C.E., AND A. E. SALTER, B.SC., F.G.S.

Excursion Secretary: HENRY BASSETT, JNR., B.SC.

(*Report by* MR. SALTER.)

HAVING arrived at Ayot Station, the sections in the brickyard close by were examined. Mr. Hopkinson described the Woolwich and Reading Beds, which are here false-bedded, and also show contortions due to the dissolution of the Chalk which lies immediately below. The London Clay was not well shown, but good sections of drift gravel and clay above the Tertiaries gave abundant scope for an animated discussion, in which the President, W. H. Hudleston, and the Directors joined. Blocks of Hertfordshire Conglomerate, quartz, etc., were seen on the floor of the pit. The drift clay seemed to be made up of disturbed London Clay, in which local material from the subjacent gravels and Chalk were mixed. *Gryphæa dilatata* from the upper portion was obtained.

A walk then followed to Welwyn, where tea was procured at the White Hart Hotel, after which two sections of gravel in the Mimram valley were examined and the great difference in the character of its constituents from that of the gravel previously seen at Ayot was pointed out.

Pebbles of various igneous rocks were readily found, having probably been washed out of Boulder-Clay farther up the valley. Mr. Salter had previously found a Palæolithic implement in one of the pits, but not one was obtained on this occasion.

The viaduct of the G.N.R. at Digswell was pointed out as showing to what extent the valley of the Mimram had been excavated in comparatively recent times.

A hearty vote of thanks to the Directors brought an interesting excursion to a close, and the party took the 6.44 p.m. train to London.

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EXCURSION TO FRINDSBURY AND UPNOR.

SATURDAY, JULY 12TH, 1902.

Directors: CHAS. BIRD, B.A., F.G.S., and W. WHITAKER, F.R.S.

Excursion Secretary: HENRY BASSETT, JUN., B.Sc.

(*Report by* THE DIRECTORS)

THE party arrived at Strood about 11.30, and proceeded to the section of the Upper Chalk in the large quarry east of Frindsbury Church, a quarry which supplies the long range of cement-works opposite Rochester with most of their limestone. They inspected at several points the various deposits of brick-earth, sands, and gravels which lie on the irregular eroded surface of the Chalk,

Length, 1½ miles, vertical scale exaggerated.

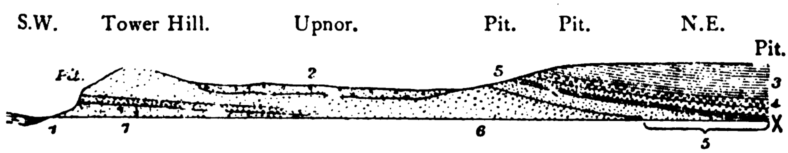

FIG. 59.—DIAGRAM SHOWING SUCCESSION ALONG THE LEFT BANK OF THE MEDWAY, NEAR UPNOR.—*W. Whitaker.*

X.—Sea-level.
1.—Alluvium.
2.—Gravel.
3.—London Clay.

Lower London Tertiaries.
4.—Oldhaven Beds; Sand, with Pebbles and Shells.
5.—Woolwich Beds; Sands, with Clay Shell-bed in the middle and Pebbles at bottom.
6.—Thanet Beds; Sand, the bottom part clayey and greenish.

7.—Chalk with Flints.

especially noting a mass of gravel and loam at the eastern end and at a lower level, in which a few fragments of shell were found. Proceeding northwards through a short tunnel they visited Tower Hill, where the Thanet Sand, with an irregular layer of green-coated flints at the base, rests on the Chalk.

Passing through Upnor village they paid a visit of some length to the large sand-pit near Upnor Church, where the upper portion of the Thanet Sands, and practically the whole of the Woolwich and Reading Beds, are to be seen, with the London Clay occurring at the top of the pit. The thin Oldhaven pebble-bed was noted, and the shelly band of that Series a few feet below the London Clay carefully examined.

The London Clay junction, however, was better seen further north behind the cement works, and the presence of a peculiar indurated layer formed by the deposition of selenite in the Oldhaven Beds was noticed, shells being sometimes replaced in sandy selenite. Numerous crystals of selenite were also found in the London Clay above; at one part there was a continuous layer at the base of the clay, and in many places the mineral was also seen along more or less vertical joint-planes. It also occurs in the clay shell-beds of the Woolwich Series. This section, indeed, is notable for its general selenitiferous character.

Mr. W. L. Wyllie, A.R.A., had invited the party to view the landscape from the platform on the top of Hoo Lodge, but time was too short for the invitation to be accepted.

The party walked back to Rochester by another route, and, after tea at the Gordon Hotel, paid a short visit to the Castle before leaving for home.

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ON A PECULIARITY IN THE COURSE OF CERTAIN STREAMS IN THE LONDON AND HAMPSHIRE BASINS.

By H. J. OSBORNE WHITE, F.G.S.

(Read June 6th, 1902).

I.

THOSE who have examined the details of the hydrography of south-eastern England cannot have failed to notice that, while the streams which drain the northern and southern slopes of the topographical depressions marking the geological basins of London and Hampshire normally pursue tolerably rectilinear paths from their sources down to their junctions with the principal west-to-east rivers following the longitudinal axes of these depressions, there are some which undergo an abrupt change of direction, whereby their lower parts assume a course roughly at right angles to that of their upper parts, and sensibly parallel to that of their appropriate main-stream. As this change of route on the part of a northerly or southerly tributary invariably takes the form of a turn in the direction towards which the adjoining section of the main stream flows, it results in the two rivers uniting at some distance below, and more or less distinctly to the east of the point at which their junction would be effected if the tributary retained its original direction.

Wanting, or inconspicuous, in many districts, such deflected courses constitute one of the most prominent features of south-western Berks, and south-eastern Dorset, near the western end of either basin; and it is with the larger examples in these two areas that the present paper is chiefly concerned.

In the Berkshire district (sheets 267 and 268, new one-inch Ordnance Map) we have, firstly, the Loddon, the greater part of whose valley, below the junction of the two principal Blackwater and Basingstoke branches at Swallowfield, has a north-eastward direction, roughly parallel to that of the neighbouring Kennet-Thames.

Next, the more marked case of the Pang, which has its origin either near Compton, on the floor of a wide transverse valley in the Berkshire Downs, or (after wet seasons) in the East Ilsley branch of that valley, further to the north-west. This stream at first flows south or south-eastwards, with the general dip of the Chalk, as though with the intention of joining the Kennet at Woolhampton, but on reaching Bucklebury it swings round to the eastward, and runs parallel to that river for a distance of about six miles, when it again turns, this time abruptly northward, and empties itself into the Upper Thames.

The Enborne, on the Berks and Hants county boundary, though less erratic, is in some respects even more interesting than the Pang, for here the deflection involves almost the entire course of the stream, giving a curiously duplicated appearance to the longitudinal drainage of this part of the London basin. Rising at, or near, the denuded crest of the Pewsey-Kingsclere anticline, below Inkpen Beacon, it flows for a few miles north-eastward, with the dip of the Tertiary rocks; then, bearing eastward, it runs for about ten miles parallel to, and at an average distance of about two miles from, the Kennet, which, by a second, north-eastward turn, it ultimately joins at Aldermaston. As a result of its prevailing eastward trend, the Enborne intercepts the bulk of the surface-drainage of the southern slope of the Kennet basin, which would otherwise be delivered directly to that river between Kintbury and Aldermaston; consequently its right-hand tributaries, if small, are numerous. On the other hand, owing to its close proximity to the Kennet throughout the greater part of its course, the Enborne receives no affluent of importance from the north: its drainage system is, therefore, singularly one-sided.

In the Dorset area (sheet 328) the Puddle, or Trent, which has its source in the North Dorset Downs, at first runs somewhat east of south, with the dip of the Chalk, but bears round to the east on approaching Puddletown, and thenceforward, for a distance of about fifteen miles, the larger curves of its valley follow those described by the Frome, down to the junction of the two rivers at the head of the Poole Harbour estuary.

The Empool Bottom brook, in the south of this district, is, in its beginnings, a north-easterly, dip-slope stream, but pursues a more eastward path for the greater part of its course through the Tertiary rocks south of the Frome, to which river it stands in much the same relation as the Berkshire Enborne does to the Kennet. Other examples could be named, but the above are the most important.

II.

Now the eastward deflection displayed by these affluents of the Kennet-Thames and the Frome may admit of more than one explanation, but it bears, in every case, so strong a resemblance to the down-stream turn which is frequently noticeable in the branches of a river system at, or a little below, the point where they quit their valleys for the alluvial flat, or flood-plain, bordering the trunk stream, that I have for some time felt disposed to attribute it, in a large measure, to similar causes. The phenomenon here referred to—which may be termed that of *postponed junction*—has been described by Fergusson,* and, probably, also by other British writers, and possesses an Italian and American literature; yet, although one of the most characteristic of flood-plain features, it is seldom discussed, or even noticed, in our text-books of geology and physiography. A simple illustration is given in the accompanying diagram

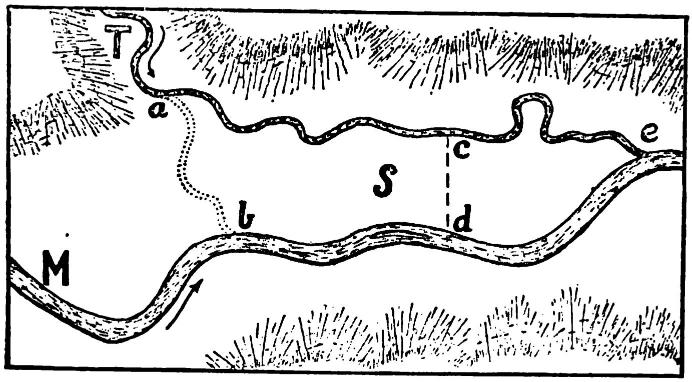


FIG. 60.

(Fig. 60), where the tributary T, on entering the valley of the main-stream M, turns abruptly to the left, and flows for some distance beside, and in the same direction as, the latter river, instead of following the more direct, and what would seem to be the more natural, course suggested by the dotted lines *a* to *b*. The deflection of the tributary in such cases is normally due to the reversing, or diverting, effect of the outward slope of the natural embankment (or levee) formed by the materials deposited along the margin of the main-stream. Being unable either to prevent the formation of this barrier across its mouth, or to build up its bed at a sufficiently rapid rate to allow of its maintaining a clear flow over the growing bank of sediment, the lesser river suffers a partial damming, and is compelled to shift its outlet, and prolong its independent course, by gradual or abrupt stages, further and further down the valley of the greater. It would seem that the conditions most favourable to this type of diversion obtain when the larger stream possesses a higher velocity, together with a much heavier burden of waste in proportion to its volume, than the smaller, and brings down to its flood-plain a significantly greater amount of material than it carries away.

Well-marked instances of postponed junction may be observed on many of the alluvial flats of south-eastern England, but for the

* "Recent Changes in the Delta of the Ganges," Q J.G.S., Vol. xix (1863), pp. 325, 342-4.

finest examples we must turn to the flood-plains of the larger continental rivers. The plains bordering the lower course of the Po, in northern Italy, exhibit the phenomenon in great perfection. One of the most remarkable cases—often cited by American writers—occurs on the growing flood-plain of the Mississippi, where the trunk of the complex Yazoo river system flows through the swampy bottom-land between the main river and the eastern side of the valley for a distance of about 200 miles, before effecting a junction. Prof. Davis remarks that "The Yazoo might pursue an independent course all the way to the Gulf (of Mexico), if the Mississippi did not happen at present to swing across to the bluffs on the eastern side of the flood-plain" at Vicksburg "and there take in the Yazoo"*

On instituting a closer comparison between the deflection of the above-named Berks and Dorset streams and the phenomenon of postponed junction, two points at once claim attention.

Firstly, in the typical flood-plain, the tongue-like space of ground (S, Fig. 60) between main-stream and diverted tributary, is necessarily of such moderate elevation as to be within reach of, at least extraordinary floods, and forms a part of the floor of the valley, or "*lit majeur*," of the larger river; whereas, in the parallel instances under discussion, this inter-stream tract rises far above the level of the enclosing rivers at their fullest, and forms a part of the high ground in which their valleys have been excavated. Therefore, on the supposition that the Enborne, Puddle, etc., owe their eastward deflection to flood-plain diversion, it is obvious that this diversion must have been accomplished at some earlier epoch of their history, when they ran at, or above, the general level of the ground now separating their lower valleys from those of the Kennet-Thames or the Frome.

Secondly, the supposed "diversion features" of these streams differ from their analogues on the modern alluvial flats of Berks and Dorset in that they are marked out on a much bolder scale; the down-turned, or deflected, sections of the tributaries being longer, and the average distance between these sections and the main-stream much greater, than in any of the recent examples. The discrepancy is, indeed, so marked that it seems, at first sight, to render the supposed identity of origin improbable, though a little consideration will suffice to show that the difference may still be largely, if not entirely, one of degree. The length of the diverted part (*a*—*e*, Fig. 60) of a tributary, is simply an approximate measure of the amount of displacement suffered by its mouth, and, taken alone, affords no indication of the rate at which that process has been carried on. The fact that

* "Physical Geography," Boston, U.S.A., and London. Ginn & Co. 1899, p. 287. For flood-plain features see also I. C. Russell, "River Development," London, John Murray, 1898, p. 123; and Humphreys and Abbot, "The Mississippi River," 1861, chap. 1-3.

this down-turned part is longer in the presumed older examples of diversion than in the actual modern ones may, therefore, merely imply that the displacement was continued over a longer period in the former than in the latter. In the determination of the average distance (*c d*, Fig. 60), between the diverted section of such a tributary and the main stream, however, time appears to be a factor of less possible importance; and the greater breadth of the inter-stream spaces associated with the supposed older instances of diversion in south-western Berkshire and south-eastern Dorsetshire seems to demand that the principal rivers of those districts (viz., the Kennet-Thames and the Frome) should formerly have possessed, not only wider flood-plains, but also greater volume, and a much higher rate of deposition, or embankment-building, than at the present day.

III.

Now the hypothesis that the deflection of the above-named streams is due to flood-plaining does not rest entirely on the strong resemblance of the one to the effects produced by the other. It finds considerable support in the physical characters of the country traversed by the lower courses of these streams; characters which more or less distinctly testify to the former prevalence of conditions analogous to those obtaining in a certain class of flood-plain over large areas of the high ground adjoining the main, longitudinal, drainage lines of the western parts of the London and Hampshire basins.

Let us first consider the evidence in connection with the very pronounced example of deflection furnished by the Enborne.

The surface of the ground drained by the Enborne and other independent southern affluents of the Kennet entering that river below Hungerford may be broadly divided, according to the characters of its prevailing slopes, into three fairly distinct zones, ranging east and west. Commencing in the south, there is, firstly, a narrow belt possessing a rapid fall in a northerly and north-easterly direction; secondly, a somewhat wider strip, of similar trend, but of more gentle inclination; and thirdly, a belt of about the same average width as the last, where the slope is very gentle and directed toward the east, and somewhat to the north of east. The first of these marks the outcrop of the chalk forming the range of high downs at the south-western margin of the London basin; the second and third, which expand eastwards, are underlain by Eocene rocks, frequently belonging to some part of the Bagshot series.

The third, or northern belt, which includes the greater part of the Enborne valley, is essentially one of flat-topped, more or less isolated, hills and ridges, capped with gravel, and forming open heaths, save where planted with pine. Among these tabular eminences there are two, which, by reason of their position and superior size, call for especial attention. These are (*a*) the long ridge of Wash, Greenham, and Crookham Commons, between the parallel valleys of the Kennet and the Enborne: and (*b*) the wider tract of moderately high ground supporting the commons of Brimpton, Tadley, Silchester, and Burghfield, to the east and south-east of the junction of those streams. When viewed from certain points on the northern side of the Kennet Valley these eminences — henceforward referred to as the Greenham and Silchester plateaux*—combine to form a striking terrace-like feature in the landscape, in marked contrast to the more uneven ground rising beyond to the foot of the boldly-undulating uplands of Sydmonton and Inkpen. Now, the prevailing slope of the ground in this northern belt being toward the east, as above noted, the crest, or upper surface, of each of these plateaux is distinctly higher at its western than at its eastern end, while the inclination of the Greenham flat (from 411 to 372 feet O.D.), on the left bank of the Enborne, is continued in the Silchester flat (from 351 to 314 feet O.D.) on the right bank of that stream. But this slope, which steadily decreases from about 10 feet per mile on Greenham Common, down to about 6 feet per mile on Burghfield Common, agrees so closely with that of the thalweg of the parallel section of the Kennet, that the crests of the plateaux maintain a fairly constant elevation of about 160 feet above the modern alluvium of that river between Newbury and Theale. The longitudinal profiles of the two slopes are, in fact, nearly parallel curves of the upwardly concave form roughly represented in Fig. 61.

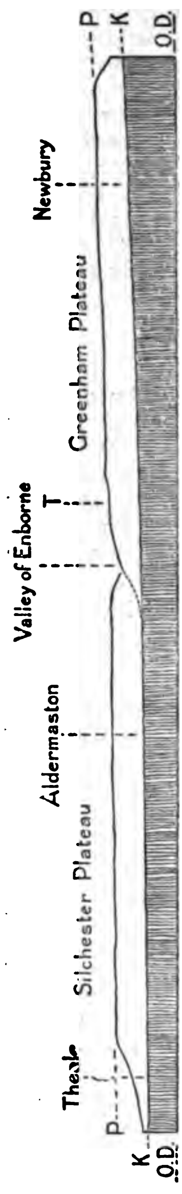


FIG. 61.—SHOWING RELATION OF THE SLOPE OF THE KENNET VALLEY TO THAT OF THE PLATEAUX TO THE SOUTH. O.D., SEA-LEVEL; K.K., PROFILE OF KENNET THALWEG; P.P., OUTLINE OF PLATEAUX; T, MINOR TERRACE. DISTANCE ABOUT 15 MILES. VERTICAL SCALE MUCH EXAGGERATED.

The stream-wrought origin of the

* "Silchester plateau"; so named by Mr. H. W. Monckton, *Quart. Journ. Geol. Soc.*, vol. xlix, p. 310.

surface of these plateaux, so strongly suggested by this coincidence, is fully confirmed by the underlying drift-beds, which present all the features common to the coarser kind of river deposits. The high-level drifts forming the widely-represented class known as "Plateau Gravel," to which these beds belong, are now, indeed, very generally admitted to be of fluviatile origin, and a large body of evidence is available in support of the view that they were laid down by the representatives of existing streams, during an earlier period in the topographical history of the regions in which they occur.

The Plateau Gravel in the neighbourhood of Newbury having been described in our PROCEEDINGS and elsewhere,* it will suffice to state that it consists mainly of subangular flints, with a variable proportion of flint-pebbles, and of more or less worn fragments of sarsen-stone, in a matrix of sand or loam; frequently exhibits strong current-bedding, with rapid changes of texture; and appears to attain its maximum thickness, of about 20 feet, under Wash Common, near the western end of the Greenham Plateau.

Possessing a wide range in elevation within comparatively restricted areas, its several sheets are clearly not the product of a single age. Nor are they logically separable, as a group, from the gravel terraces of the valleys, into which they occasionally merge. They are rather to be regarded—as Mr. Monckton† has recently urged in the case of their representatives in the adjoining Bagshot district—as the older, and usually more strongly developed, members of a graduated succession of deposits, of similar character and habit, ranging downwards through the terraces of River Drift, to the Valley Gravels at, or but little above, the level of the recent alluvium.

The task of correlating such stair-like deposits is rarely unattended by grave difficulties. Their vertical frequency, their lateral discontinuity, the gradation of older into newer, our ignorance of the gradients of their responsible streams at the time of their formation; all these circumstances are prejudicial to the satisfactory identification of contemporaneous sheets, even within the limits of so small a basin as the Kennet's. Still, among the many gravel-flats and terraces of the Newbury district it is possible to trace a few well-defined stages, of which that including the beds on the Greenham and Silchester plateaux is by far the most marked. The dimensions of these plateaux, particularly the (north to south) width of the second, alone suffice to show that this stage was one of considerable importance in the history of the Kennet basin. Yet these two gravel sheets are but

* Bristow and Whitaker, *Geol. Surv. Memoir*, on Sheet 12 (1862), pp. 38, 43, 44; Prestwich, *Quart. Journ. Geol. Soc.*, vol. xlvi (1890), pp. 161-2; Monckton, *Quart. Journ. Geol. Soc.*, vol. xlviii (1892), pp. 39, 40; vol. xlix (1893), p. 310; vol. liv (1898), p. 191. Richards, *Quart. Journ. Geol. Soc.*, vol. llli (1891), pp. 420-1. Blake, *Proc. Geol. Assoc.*, vol. xvi (1900), p. 513.

† "Origin of the Gravel Flats of Surrey and Berkshire," *Geol. Mag.*, New Series, Dec. iv, vol. viii (1901), p. 511.

remnants of a far more extensive spread, that seems to have involved the whole of the area of moderately accidented country roughly defined by the Hungerford, Reading, and Aldershot triangle. It is interesting to notice that while no part of the ground within this area attains an elevation significantly greater than 160 feet above the level of the nearer of the two principal streams (viz., the Kennet and the Blackwater-Loddon) at its nearest point, this height limit is reached, or closely approached, by many large gravel plateaux—including those of Greenham, Bradfield, Silchester, Hartford Bridge Flats, and Finchampstead Ridges—and by a number of well-defined terraces bordering the higher ground on the north, south, and east. The coincidence may be an accidental one, but when taken in connection with the general centripetal trend and inclination of the above-named plateaux, it certainly suggests that the existing relief of this area has been carved out of a drift-mantled plain of subaërial erosion, whose gentle slopes converged, like the sides of a shallow funnel, towards a point somewhere in the vicinity of the site of Reading.

But whatever the original extent of the great gravel-sheet of (what may be termed) the "Silchester" stage, the relics in the neighbourhood of Newbury plainly indicate, (1) that when the effective base-level of erosion of the district stood about 150 feet higher than at present, it remained practically stationary for so long a time that a broad and shallow vale, or "bottom," was opened out in the weak Tertiary beds along the main-line of drainage; and (2) that the surface of this depression was strewn with a mass of stream-borne waste, derived from the surrounding slopes. The formation of this vale is, doubtless, to be ascribed (like that of the existing Kennet Valley) in a large measure, to the lateral corrasion of the streams responsible for the drift covering its floor; though the considerable width of the reduced area—not less than six miles in the longitude of Newbury, and the gradual manner in which many of the outlying terraces forming the relics of its marginal portions merge into the steeper slopes of the enclosing high ground, convey the impression that the bulk of the work of planation was performed by the relatively slow process of subaërial degradation.

It is possible that the spreading-out of the gravel proceeded *pari passu* with planation; the area of deposition slowly expanding as the floor of the valley gained in width, and more and more ground was brought within reach of the streams; but there are indications that the drift which has been preserved to us on the plateau and terraces of the Silchester stage was laid down when the work of reduction was practically completed, and by streams of small erosive power. Evidence of this is seen in the westward, or up-stream, thickening of the deposits on the larger plateaux, near the median line of the old valley, and also, perhaps, in the distinct, obliquely-transverse slope away from the Kennet which is noticeable in the surface of the Greenham plateau; the former pointing to an aggradation (or increase of gradient by deposition), the latter to an embanking of the main river—and therefore also of its tributaries—such as one associates with streams of constructive, rather than with those of destructive, tendencies.

The gravel appears, in fact, to date from near the close of the Silchester age, when, owing to some change—presumably of a climatic nature—the main-stream and the tributaries entering it below Hungerford could no longer transport the material they acquired in their upper courses down the gentle slopes of their lower courses through the Tertiary lowland, and were compelled to employ a portion of their load in raising the gradient of their beds, and in partially filling-up the wide depression they had previously helped to produce. The greater part of the excess of rock-waste seems to have been deposited in the form either of broad stream-embankments of low profile along the axis of this depression, or of confluent fans, sloping inwards from its margin. To judge from the internal structure and the composition of the gravel, the overloading of these streams was occasioned, not by any diminution of their volume, but by the more rapid supply of débris—the bulk of which was derived from the Chalk, or more probably from the flinty soil overflowing that rock on the higher slopes of the basin—arising from an increase in the rate of denudation.

With regard to the size of the principal, west-to-east, river of the district at this time, it may be noted that although this river had long ceased to deepen its valley, and (so far as one can judge by the slope of the larger plateaux)* was spreading out its gravel at about the same inclination as that of the recent alluvium of the existing, approximately-graded Kennet, it by no means follows that its volume was not appreciably greater than that of the latter stream. It has often been stated—sometimes without any qualification—that the angle of slope at which a river ceases to lower its channel varies inversely as the volume of water, or, in other words, that the larger the river the gentler is its "final" slope. This angle, however, depends not merely on the volume of the stream, but also on the mass and texture of the débris which it has to transport; and a smaller river with a light load of fine material may have a profile of equilibrium with gradients appropriate to that of a larger one with a heavy burden of coarse detritus.† In view of the distribution, internal structure, and generally coarse character of the deposits on the plateaux and

* The (mainly elevatory) earth movements affecting this district in post "Silchester" times do not appear to have produced any sensible amount of deformation.

† See W. M. Davis, *op. cit.*, p. 243. Also, "Physical Geography in the University," *Journ. Geol.*, vol. ii (1894), p. 78; and "Baselevel, Grade, and Peniplain," *ibid.*, vol. x (1902), pp. 77-111. The last-named article, of whose existence I was not aware until after the reading of the present paper, is one that should be consulted by all who are interested in the life histories of rivers and land-forms.

terraces of the Silchester stage, it is highly probable that the Kennet was then both swifter and larger than at the present day, but so much more heavily loaded with gravel as to be incapable of carrying on the work of transportation with a distinctly lower gradient. The former greater volume of the Kennet is also to be inferred from the loss of drainage area it has suffered, and is still suffering, by the encroachment of the Salisbury and Bristol Avons, and of the subsequent branches of the upper Thames to the north of Berkshire and Marlborough Downs.* The amount of shrinkage due to this cause since the date here referred to, however, is probably trifling as compared with that arising from lessened precipitation.

From the foregoing remarks it may be gathered that the even and gently-inclined surface of the ground enclosing the valley of the Enborne, and separating it from that of the Kennet, is not only the work of fluviatile agencies, but a result of the two distinct processes of planation and aggradation responsible for a large class of flood-plains. The drift beds underlying this surface differ, it is true, from those found in the modern flood-plains of the south-east of England, in consisting almost entirely of gravel, but there is no reason to doubt that they belong to the same order of fluviatile deposits.

The conditions under which these beds were laid down were of a kind particularly favourable to stream diversion of the "postponed junction" type, and although it cannot positively be asserted that these conditions were responsible for the eastward deflection of the Enborne, the fact that the greater part of the valley of that stream has been carved out of the floor over which they prevailed certainly tends to confirm this view. Indeed, the Enborne appears to owe, not only its direction, but its very existence as a hydrographical unit to the damming and downstream turning influence which the overburdened Kennet brought to bear upon a group of small, southern, tributaries towards the close of the Silchester stage.

IV.

Similar evidence is forthcoming in the case of each of the other deflected rivers mentioned in the beginning of this paper. In every instance the ground enclosing the deflected part of the tributary, or serving as a barrier between it and the main stream, is, in a large measure, overspread with sub-angular gravel of fluviatile origin, forming more or less well-defined plateaux, with a prevailing slope in the direction pursued by the latter river. Where the individual plateaux are sufficiently large, or sufficiently close together, to enable one to distinguish their purely local

* Auct. cit. *Geographical Journal*, vol. v (1895), No. 2, pp. 144-5. See also, *S. S. Buckman Nat. Sci.*, vol. xiv (1899), No. 86, p. 282; and *Proc. Cotteswold, Nat. Field Club*, vol. xiii (1900), pp. 187-9.

s, due to irregularities of constructional or destructional ı, from their general gradients, the latter are commonly l to approximate fairly closely to those of larger neighbouring valleys.

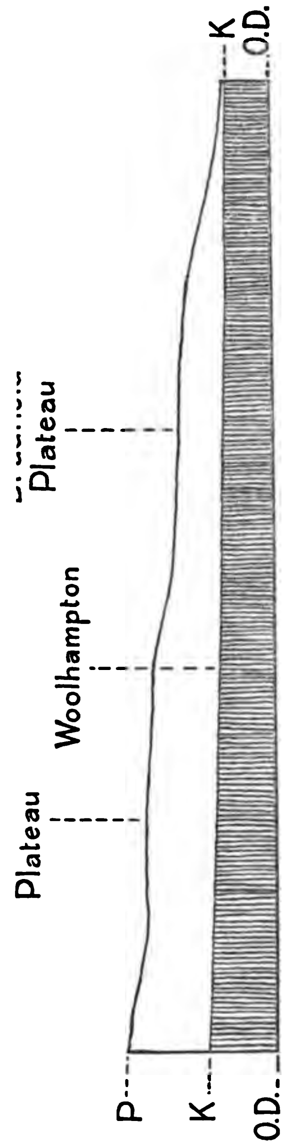


FIG. 62.—Showing the terraced character of the summit of the ridge between the Pang and the Kennet. O.D., sea-level; K K, profile of the Kennet thalweg; P, outline of the plateau-ridge. Distance, about nine miles.

There is, however, an important feature of the drift-covered country bordering the lower courses of these rivers to which no reference has as yet been made, viz., the composite form of the crest, or upper surface, of the ground intervening between deflected tributary and main-stream. Close observation is rarely needed to apprise one of the fact that the continuity of the longitudinal crest slope of such inter-stream tracts is broken by two, three, or more tolerably distinct terraces, of which the lower lie nearer to, and the higher more remote from, the point of junction of the two streams. The larger terraces, which are generally among the higher of the series, are almost always represented at similar or appropriate levels in the surrounding district by other terraces, or plateaux, marking important stages in the development of the existing topography. It not infrequently happens that the greater part of the whole available area of the summit is occupied by some one member of the stair-like succession; the Greenham Common ridge, between the Kennet and the Enborne, where the predominance of the highest terrace gives the whole feature the aspect of a single plateau, being an extreme instance of this kind.

The composite character of the inter-stream surface is well shown in the high ridge separating the Kennet from the Pang, part of whose outline is indicated in Fig. 62, P. The less inclined sections of this line mark the position of two gravel flats; the higher underlying Bucklebury Common, the lower, which is much dissected, supporting Bradfield Common and South End, and forming the top of the spur running north-east from Beenham. The Bucklebury plateau has a gently undulating surface, and is probably of more than one age, though no clear line of demarcation can be drawn between its constituent parts, but the break between it and the Bradfield flats, which belong to the Silchester stage, is marked by a disappearance of the drift, and by an increase of slope very perceptible in the field.

The long, stony, heath-covered tract, between the Dorset Puddle and the Frome, exhibits a yet more broken character.

Now, these stair-like inter-stream tracts bear so obvious a resemblance to the complex "junction terraces" described by Miller,* that it is difficult to resist the conclusion that they have a very similar origin, and that their constituent flats mark, approximately, the successive portions of the confluence of the streams on either side. In the majority of the examples here referred to the enclosing rivers drain the same kinds of rock, and their alluvia being therefore indistinguishable, it is impossible to determine whether these terraces belong to one alone or to both. In the drift deposits between the valleys of the Lower Loddon and the Thames, however, both rivers are clearly represented, and Mr. Monckton† has noted the lateral passage of the cherty gravel of the former into the quartzite gravel of the latter, near the northern end of the Sonning-Earley plateau, some three miles to the south-west of, and above, the present junction of these streams.

While, then, the surface-form of these interstream areas tends to confirm the view expressed in this paper with regard to the significance of the deflection of above-mentioned tributaries of the Kennet-Thames and the Frome, it also serves to show that this deflection is the product of more than one, and perhaps of many, ages. Thus, the diversion of the once independent affluents of the Kennet now forming the Enborne appears to have been effected at the Silchester stage, but the presence of a minor terrace (marked T, Fig. 61) at the eastern end of the Greenham plateau, suggests that the Enborne itself received a slight accession to its length at a somewhat later time. Much of the lower course of the Pang also dates from the Silchester stage, but here diversion clearly began earlier, for the Bucklebury plateau, on the higher

* "River Terracing," *Proc. Roy. Ph. Soc.*, Edinburgh, vol. vii (1881-3), pp. 287-8.
† *Quart. Journ. Geol. Soc.*, vol. xlix (1893), p. 312.

art of the ridge, between this stream and the Kennet, rises about o or 70 ft. above that datum.

The course of the Loddon below Swallowfield is a growth of nany stages, all, apparently, of post-Silchester date.

In the Dorset area, the displacement of the mouth of the 'uddle was probably accomplished mainly during the epoch of he local "Older Plateau Gravel" of Puddletown Heath, Affuddle Heath, and Stokeford Heath, on the relatively high round between that stream and the Frome: further developnents, however, took place during the deposition of the "Newer 'lateau Gravel" covering the lower step of Stokeford Heath, ear the eastern end of this inter-stream area,* and at still later tages, down to the level of the modern marsh-land.

The Empool Bottom brook seems, like the Enborne, to have esulted from the obstruction, and consequent combination in a ingle trunk, of a group of small, north-eastward, streams tributary o the Frome; the diversion in this case dating from the time of he Newer Plateau gravel.

The prevalence of deflected streams near the western end of oth the London and Hampshire basins, which was referred to at he commencement of this paper, shows that the conditions there ave been exceptionally favourable to diversion. The reasons or this are not very apparent, but a possible explanation is to be ound in the closing-in of the synclinal folds determining these asins, whereby the marginal uplands of comparatively resistant Chalk occur in close proximity to the main, longitudinal, lines of rainage established on the tongues of easily reduced Tertiary ocks in the bottom of the troughs. With a more abundant queous precipitation, and a higher rate of denudation, such as ave, at times, undoubtedly prevailed in the past, the steep Chalk lopes ensured by this conjunction would yield a rapid supply of oarse débris immediately to the principal water-ways, thus lacing them, locally, in the heavily burdened condition in which hey would be most likely to divert their tributaries in these listricts.

V.

The deflected parts of all the streams so far dealt with are estricted to somewhat narrow zones bordering the Kennet-Thames or the Frome, where the relatively high rate of erosion and the veakness of the rocks have been especially conducive to the levelopment of open valleys and wide flood plains during the nore prolonged of the numerous pauses which have interrupted he (generally) negative, or downward, displacement of the base-evel of southern England. I propose to conclude this paper with a brief notice of an interesting little example of postponed

* C. Reid. "Geology of the Country around Dorchester. *Mem. Geol. Surv.*, 1899, pp. 40-42.

junction connected with a southern affluent of the lower Frome, but situated at some distance from, and not attributable to, the influence of the latter river.

This occurs in the Isle of Purbeck (Sheet 343, one-inch Ordnance Map, New Series Geological), where the eastern and western branches of the Corfe River, flowing inward from near either end of the longitudinal valley which marks the outcrop of the Wealden Beds, turn northward on approaching one another at Corfe, and traverse the Chalk ridge in sharply cut gorges, separated only by the narrow and precipitous Castle Hill, ere they unite, at the margin of the Eocene Beds. (Fig. 63.)

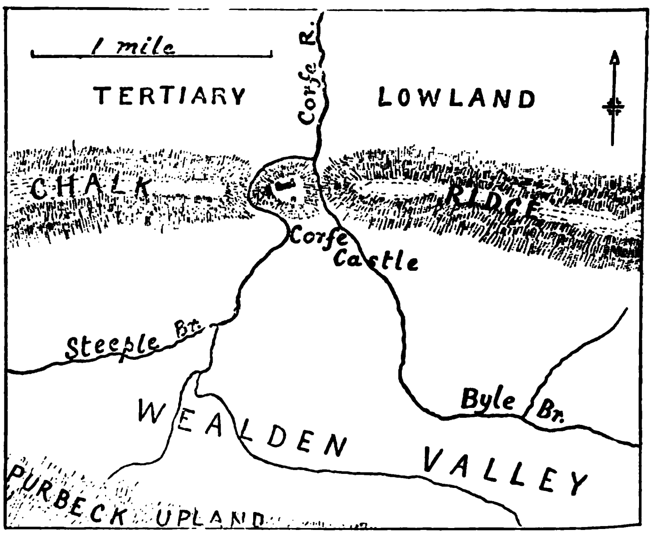


FIG. 63.—SKETCH MAP OF THE VICINITY OF CORFE CASTLE, ISLE OF PURBECK.

The generally accepted explanation of this curious double breach in the Chalk appears to be that offered by Mr. Strahan,* who—if I rightly understand his somewhat brief remarks—considers it to have been initiated by a pair of streams engendered on the northern slope of the Purbeck anticline, at a time when the arch of the fold was unbroken, and its drainage still essentially of the consequent order. But while there is no reason to doubt that, from a very early stage in the physiographical development of the district, an appreciable fraction of the drainage of the Purbeck anticline has passed transversely over, or through, the existing Chalk ridge in the near vicinity of the site of Corfe Castle, it may none the less be questioned whether

* "Geology of the Isle of Purbeck and Weymouth." *Mem. Geol. Survey* 1898, p. 233.

the dual manner in which its passage is at present effected can boast of nearly so high an antiquity.

The chief objection to this view arises from the arrangement, and the great difference in the powers of resistance, of the rocks exposed by denudation in the southern part of the Isle. The outcrop of the yielding clays and sands of the Wealden Series, interposed, as it is, between that of the more durable Purbeck limestones and that of the locally indurated Chalk, has long formed a peculiarly favourable field for stream adjustment, as may be seen by the well-marked subsequent character of its drainage; and it seems quite improbable that two streams engaged in cutting down their channels through this belt of weak rocks, and through the succeeding sill of hard Chalk, in such close proximity, could have preserved their independence for so long a period as that implied in the above hypothesis. Unless their rates of vertical corrasion in the controlling stratum (*i.e.*, the Chalk) were balanced to a remarkable degree of nicety, one or the other of these streams would surely have gained sufficient advantage to enable it to decapitate its neighbour on the south side of the Chalk ridge, long ere this.

It is true that the western, or Steeple Brook,* branch of the Corfe River has acquired a large share of the drainage area of the eastern, or Byle Brook branch, and seems destined, by the aid of the encroaching Swanage stream, to reduce the eastern breach in the chalk ridge to the condition of a wind-gap; but when regarded as the outcome of a life-long struggle, its gain so far is pitifully insignificant.

A decidedly more probable view is that recently brought forward by Mr. W. H. Hudleston,† viz., that the eastern and western branches of the Corfe formerly united on the south side of the Chalk outcrop, and traversed it by a single channel; and that when this channel had been cut down to about the level of the summit of the Castle Hill (about 170 ft. below the ridge on either side), the two streams became separated, and commenced to carve out independent gorges.

Mr. Hudleston offers no suggestion as to the cause of the separation of these streams, but a northerly displacement of their junction, under flood-plain conditions, during a temporary cessation of the down-cutting process, seems by far the most natural explanation.

There are indications that the Byle Brook, though now the smaller, played the part of main-stream, or divertor, in this change. If this was actually the case, then the western gap must be regarded as an accidental feature, due to the local superimposition of the diverted longitudinal Steeple Brook upon the Chalk, from the alluvium covering the floor of the original, single, transverse valley.

* Also known as the Wicken Brook.

† "Guide to Wareham" (Bright's, Ltd., Bournemouth), 1900, p. 38.

NOTE ON THE OCCURRENCE OF MICROTUS INTERMEDIUS IN THE PLEISTOCENE DEPOSITS OF THE THAMES VALLEY.

By MARTIN A. C. HINTON AND GILBERT WHITE.

(Read June 6th, 1902.)

IN 1882 Mr. E. T. Newton, in the Geological Survey Memoir on the Vertebrata of the Forest Bed Series, described and figured the fossil remains of a vole which, in the general pattern of the prismatic molars, agreed very closely with the existing *Microtus amphibius*, but which was clearly distinguished from the latter, not only by its smaller size, but by the very important character of having the molars rooted, whereas in *M. amphibius*, as in other true voles, the molars are never rooted, being developed from permanent pulps. The occurrence of these rooted molars, therefore, indicated the existence in Newer Pliocene times of a vole which, though undoubtedly possessing affinities with the existing water-vole, nevertheless belonged to a more generalised type, making as it did a nearer approach to the ancestral stock of murines of a branch of which the true voles are now generally regarded as being the highly specialised descendants. For this interesting and new species Mr. Newton proposed the name of *M. intermedius*, and hitherto, so far as English deposits are concerned, it has only been recognised from the Forest Bed Series and the Norwich Crag.

The Geologists' Association last year visited a section at Greenhithe in Kent which exposed a very fossiliferous development of the hitherto barren High Terrace deposits of the Thames Valley. Recently one of us obtained a cheek-tooth of a large vole from these beds, which proved to be a right first lower molar. The posterior prism is unfortunately broken, and the anterior extremity is slightly mutilated. Enough remains, however, to indicate an enamel pattern of three outer and four inner angles, or similar to that of the corresponding tooth in *M. amphibius*, for which species it, at first sight, might easily be mistaken. Closer examination shows that in the first place the enamel infolds are not so deep as in *M. amphibius*, and thus the tooth presents prisms more confluent with one another. So far as enamel pattern is concerned, this is the sole point of distinction between *M. intermedius* and *M. amphibius*. The specimen, though belonging to a young individual, distinctly shows signs of rooting in the partial closing of the cavities for the dentinal pulp. This latter character clearly allies the specimen to *M. intermedius*, and taken in conjunction with the pattern and comparatively small size, we have no doubt as to its identity with Mr. Newton's species.

If our specimen is compared with the tooth figured by Mr. Newton in Fig. 3 of Pl. XIII of the work before cited, the closest resemblance as regards pattern is seen between them, the only difference being the more confluent character of the example before us.

ORDINARY MEETING.

FRIDAY, MARCH 7TH, 1902.

H. W. MONCKTON, F.L.S., F.G.S., President, in the Chair.

Alfred Ernest Greene was elected a member of the Association.

A paper was then read by Dr. A. W. ROWE, F.G.S, on "The Zones of the White Chalk of the English Coast. III.—Devonshire." The paper was illustrated by lantern slides taken by Prof. Armstrong, and by sections drawn by Mr. C. Davies Sherborn.

ORDINARY MEETING.

FRIDAY, APRIL 4TH, 1902.

H. W. MONCKTON, F.L.S., F.G.S., President, in the Chair.

Richard Edward Goolden, F.S.A., Allan McDonald, M.A., LL.D., and A. P. Young were elected members of the Association.

A lecture on "Klondike, its Geology and Mining" was delivered by Prof. H. A. MIERS, M.A., F.R.S., and was illustrated by lantern slides.

ORDINARY MEETING.

FRIDAY, MAY 2ND, 1902.

H. W. MONCKTON, F.L.S., F.G.S., President, in the Chair.

The following were elected members of the Association: Tempest Anderson, M.D., B.Sc., F.G.S., Rodolph F. De Salis, F.G.S., William Evans, M.R.C.S., L.R.C.P., John S. Flett, M.A., M.B., D.Sc., F.R.S.E., Arthur Holborow, W. H. Pratt, Miss Emma Simpson, J. T. Stobbs, F.G.S., Herbert R. Sykes, Charles E. Willows, L.D.S.

A lecture was then delivered by Prof. W. W. WATTS, M.A., Sec. G.S., on "The Geology of Charnwood Forest," and was illustrated by specimens and lantern slides.

A SKETCH OF THE LATER TERTIARY HISTORY OF EAST ANGLIA.

By F. W. HARMER, F.G.S.

(Read July 4th, 1902.)

PART I.—THE PLIOCENE PERIOD.

INTRODUCTORY.

THE President of the Geologists' Association has asked me to prepare, for the use of those taking part in the proposed excursion to East Anglia, a résumé of the views I have published in some recent papers on the later Tertiary deposits of the East of England.

The object of those papers was to trace out as far as possible the conditions under which the latter were accumulated, and their relation to each other, rather than to attempt any detailed description of the deposits themselves, a task which had been exhaustively performed by the officers of H.M. Geological Survey. No apology is made therefore for treating the subject in a similar and perhaps a somewhat popular way. On this occasion a bird's-eye view, even if more or less out of focus, may be useful; a working hypothesis, if somewhat speculative, may provoke discussion and lead to further inquiry.

As is well known, the geological history of the Pliocene epoch forms the introductory chapter to that of our own times, the general features of the British Isles having by that period assumed, more or less, the character under which we know them.

This is also true to a considerable extent of the East Anglian region, although the fact has not always been recognised by geologists. While the latter were discussing such physiographical problems as the depth of the Crag sea, at one stage, it was thought by some, reaching 500 or even 1,000 feet,* the mother wit of the peasants of Suffolk and Essex had led them straight to the heart of the matter. Speculating as to the origin of the beds of "cockle shells" so frequently met with, and familiar with the occasional irruption of the tides upon the low-lying lands of the coast, they have often expressed to me their simple explanation: "the sea once came as far as this." They were right, the shores of East Anglia were bathed during the Crag period, as they are to-day, by the German Ocean, which then extended somewhat further to the west. My compatriots do not realize, however, as we now do, that the Rhine and its affluents were

* *Quart. Journ. Geol. Soc.*, vol. xxvii, p. 135, 1871.

bringing into it, as they have been ever since, the sediment from which the Pliocene and to some extent the post-Pliocene deposits of the Anglo-Belgian basin have been built. The more distinctly we can keep these facts in view, the more easy it will be for us to understand the physical conditions of our later Tertiary history.

The subject must, however, be treated as a whole. The solution of the Pliocene problem cannot be arrived at by the study of isolated sections, or of limited areas. It will be especially necessary, in the first instance, briefly to refer to the Pliocene deposits of Belgium and Holland.

THE OLDER PLIOCENE DEPOSITS OF THE SOUTH OF ENGLAND, AND OF BELGIUM AND HOLLAND.

The researches of Mr. Clement Reid have given us a list of between 60 and 70 species of Mollusca from an Older Pliocene deposit at Lenham, on the North Downs of Kent, 600 ft. above the sea.* These Lenham beds are represented by a portion, at least, of the ferruginous sandstones of Louvain and Diest, with which they are connected by a series of outliers, always on comparatively high ground, and often capping isolated hills, as, for example, at Cassel, in the north of France, which one passes on the left hand, at no great distance from the railway, when travelling from Calais to Lille (Fig. 64).

The Diestien sandstones (*Zone à Terebratula grandis* of Belgian geologists) are for the most part unfossiliferous, but about sixty species of Mollusca are known from them. The greater part of these are characteristic Crag forms, but some are of an older type, as, for example, *Pyrula reticulata*, *Murex scalariformis*, *Conus dujardinii*, *and Pleurotoma intorta*, common in the North Sea in Miocene times, but either unknown from the Coralline Crag, or dying out in that region during its deposition.

The Lenham fauna is of a similarly mixed character. It includes on the one hand a number of common Crag shells, and on the other, well-known Miocene or Older Pliocene species, such as *Terebra acuminata*, *Triton heptagonum*, *Pleurotoma consobrina*, *P. jouanettii*, *Cancellaria contorta*, *Hinnites cortesyi*, and, in great abundance, *Arca diluvii*. The last species is very common in the Miocene beds of Belgium (Bolderien), but, as far as we know, it had disappeared from the Anglo-Belgian basin before the deposition of

* Pliocene deposits of Britain, Mem. Geol. Survey, p. 236, 1895. The Lenham Beds were first described by Prestwich and S. V. Wood in 1858, *Quart. Journ. Geol. Soc.*, vol. xiv, p. 322.

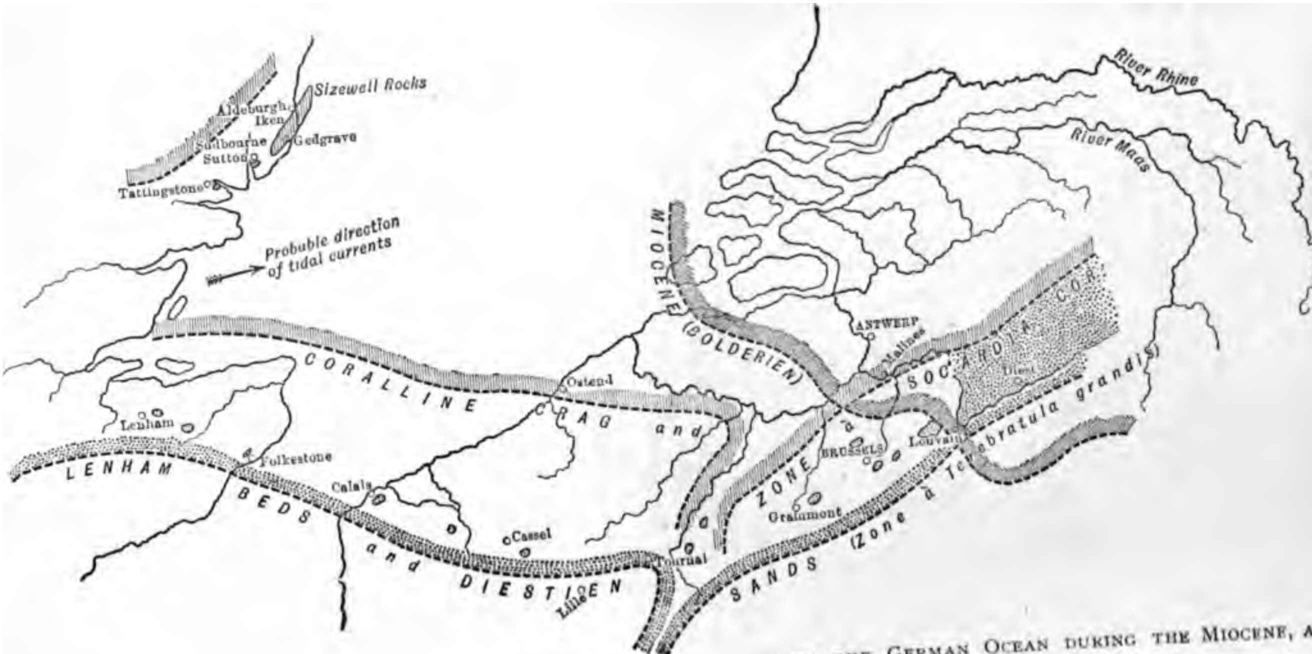


FIG. 64.—MAP SHOWING THE PROBABLE WESTERN AND SOUTHERN LIMITS OF THE GERMAN OCEAN DURING THE MIOCENE, AND ... THE CASTERLIEN AND DIESTIEN PERIODS. (Scale : 1/2,500,000 = about 39 miles to the inch.)

... permission, from the *Quart. Journ. Geol. Soc. vol.* liv, *p.* 316.) ... the periods in question, is taken from some maps published by M. Rutot.

the Coralline Crag. On the other hand Astartes, which occur in prodigious numbers in the Coralline Crag, are rare at Lenham.

A third fossiliferous deposit, possibly of similar age, although perhaps somewhat older, occurs at Waenrode, 6 or 7 kilometres south of Diest,* from which fourteen species of Mollusca have been identified, most of them being found in the English Crag.

The Waenrode deposit also contains an admixture, with species of a recent type, of some of an older character, as, for example, *Pyrula reticulata*, *Cardium subturgidum*, and *Isocardia lunulata*, together with three others, the identification of which is uncertain, referred to the Miocene forms, *Cassis rondeletti*, *Pecten callaudi*, and *Lucina drouetti*.†

We may turn now to the fauna of the well-known box-stones, which occur at the base of both the Coralline and the Red Crags, and resemble the rounded pebbles of a modern beach. They are composed of ferruginous sandstone of similar character to that of the Diestien beds, and represent an early stage of the invasion of East Anglia by the Pliocene sea, a basin at that time open to the south and closed to the north. Casts of the following species of Mollusca have been obtained from the box-stones:

Cassidaria bicatenata,	*Cardium decorticatum*,
Conus dujardinii,	*Cyprina islandica*,
Nassa conglobata,	,, *rustica*,
Pyrula reticulata,	*Glycimeris angusta*,
Trochus zizyphinus,	*Isocardia cor*,
Voluta lamberti,	,, *lunulata*,
,, *auris-leporis*,	*Panopœa faujasii*,
Dentalium dentalis,	*Pecten opercularis*,
	Pectunculus glycimeris.

Here again we find the same admixture with common Crag forms, of those of an older type, as for example *Conus dujardinii*, *Nassa conglobata*, *Pyrula reticulata*, and *Voluta auris-leporis*. The individual species are not identical in the four cases just mentioned, but this is not remarkable, since their total number is very small, perhaps not one seventh part of the molluscan fauna of the North Sea at that period; their general character is, however, the same, and points to the conclusion that the deposits in which they occur are approximately of similar, and, I think, of Older Pliocene age.‡

It seems probable that these various deposits of the South East of England and of Belgium had been consolidated and upraised, although not to their present height, before the com-

* *Ann de la Soc. Malac. de Belgique*. T. 19, p. 29, 1884.

† It should be stated that M. Vanden Broeck considers the Waenrode bed to be of Miocene age.

‡ Prof. Ray Lankester took a similar view as to the boxstones in 1870. *Quart. Journ. Geol. Soc.*, vol. xxvi, p. 500.

mencement of the Newer Pliocene period, and that they formed then the southern margin of the Crag sea.

As so few fossiliferous exposures of these beds are known, and the total number of specimens obtained from them is small compared with that of the East Anglian Crag, the species named probably represent some of the more abundant fossils of the strata in which they occur. Comparing them with the characteristic Mollusca of the Coralline Crag, their general facies seems to be of an older type than that of the latter; omitting those found only in the bed at Waenrode, the age of which is thought by foreign geologists to be Miocene, they contain 48 per cent. of extinct species, compared with from 36 to 38 per cent. in the case of the Coralline Crag.

THE NEWER PLIOCENE DEPOSITS OF BELGIUM AND HOLLAND.

Casterlien (*Zone à Isocardia cor.*).

Excavations in the low ground near Antwerp (Fig. 64). at some distance from the range of hills referred to, have brought to light some glauconiferous deposits to which the name *Zone à Isocardia cor.* was given in 1874, by M. Cogels. They were formerly regarded as equivalent to the ferruginous sandstones of Louvain and Diest, but M. Vanden Broeck considering them, and I think with reason, to be newer, has called them Casterlien. Although the number of species obtained from the latter is considerably smaller than that from the Coralline Crag, the correspondence between the two deposits is so close that they are doubtless of similar age. One difference, however, should be noticed. The fossiliferous sands of Antwerp represent, in M. Vanden Broeck's opinion, an undisturbed sea bottom; their lamellibranchiate Mollusca are found with both valves united, and apparently in the position of growth. The Coralline Crag, on the contrary, is composed of drifted sediment, almost entirely organic, consisting of shells or Polyzoa,* or of material derived from their decomposition.

The Casterlien deposits differ, moreover, from the Coralline Crag in that they contain in prodigious numbers, the fossil remains of marine Vertebrata, especially of cetaceans, pinnigrades and cartilaginous fishes.

Referring to the wonderful collections in the Museum at Brussels, Mr. Vanden Broeck says :—

"D'énormes grillages, adossés aux murailles de certains vestibules, contiennent plus de deux cents mètres cubes d'ossements

* Polyzoa of similar species to those of the Coralline Crag are found in great abundance in the neighbourhood of Antwerp, in beds considered to be equivalent to the *Sables à Isocardia cor.*

de cétacés, provenant du déchet des doubles, et qui ont été ainsi réunis afin de donner au visiteur étonné, une idée de l'incroyable quantité de baleines qui hantaient le golfe d'Anvers à cet époque. Si nous ajoutons encore, qui l'on peut évaluer à 50,000, le nombre d'échantillons choisis d'ossements de vertébrés qui se trouvent actuellement exposés au Musée, il nous restera, croyons-nous, plus rien à ajouter à ce sujet."*

Our bird's-eye view of the history of the Pliocene period would be incomplete without a passing reference to these mighty denizens of the Crag sea, which, although not known from our English deposits, must have visited from time to time the East Anglian coasts.

The vertebrate fauna of the German Ocean at this period was extraordinarily rich, but it cannot be supposed that marine animals could have existed at one spot in numbers corresponding to those of these Antwerp fossils. As M. Vanden Broeck remarks, the Gulf of Antwerp must have been a veritable cemetery. A possible explanation of the facts may be that a series of sand banks then lay off the Belgian coast, running more or less parallel to it. During the prevalence of north-westerly gales, cetaceans or sharks might have been stranded on these banks, and afterwards carried over into the deeper water between the latter and the land, where they would have been caught as in a trap, unable to escape. That the fossil skeletons of such animals are not found in the Coralline Crag seems to indicate that the epoch of easterly gales in the Crag region alluded to on p. 437 had not then commenced.

Deep borings in Holland, the details of which we owe to my friend Dr. J. Lorié, of Utrecht†, shew that the Casterlien deposits‡ extend northwards under the more recent strata of that country, dipping as well as thickening as we trace them in that direction. They are more than 300 ft. in thickness at Utrecht, the boring at that place being carried to a depth of 1,200 ft. without penetrating them (Fig. 65). The beds reached in these Dutch borings, now eight in number, shew an absence of the characteristic Miocene and older Pliocene Mollusca, before alluded to, which give an older facies to the deposits of Lenham and Diest.

Scaldisien (*Zone à Trophon antiquum*).

Overlying the Casterlien strata in the neighbourhood of Antwerp, are some stratified sands containing drifted shells,

* M. Vanden Broeck gives a list of 17 species of cetaceans, 16 of pinnigrades, and 30 of sharks &c., from these deposits. *Esq. Géol. des dep. Plioc. d'Anvers, Bruxelles*, 1876, p. 120.

† *Contr. à la Géol. des Pays-Bas, Archives Teyler*, Ser. 2, 1885.

‡ Alluded to as Diestien in my paper on "The Pliocene deposits of Holland." *Quart. Journ. Geol. Soc.*, vol. lii, p. 748, 1896.

for which M. Cogels proposed in 1874 the term *Sables à Trophon antiquum*; but which are now generally known as Scaldisien. They are specially characterised by the abundance of the sinistral form only of the common whelk, from which they take their name. In this the Scaldisien resembles the Crag of Walton-on-the-Naze, as it does in the almost exclusively southern character of its molluscan fauna, and the two deposits are probably synchronous. The Scaldisien strata may also be traced northwards into Holland, dipping and thickening in that direction as do the Casterlien beds (Fig. 65).

In Belgium, where they attain no great thickness, the Scaldisien beds may represent the marginal deposits of the south-eastern shores of the Crag sea, but at Utrecht, where they are 120 ft. thick, they may indicate an undisturbed sea bottom.

An upper zone of the Scaldisien, the Poederlien of M. Vincent, containing a fauna practically identical with that of the former, except that it contains a few northern shells, as for example *Trophon* (*Neptunea*) *despectus*, and *Pecten islandicus*, seems to be more or less the equivalent of the Oakley horizon of the Walton Crag, to be described hereafter.

Overlying the Scaldisien strata at Utrecht, and reached also in borings at Amsterdam, are some beds, nearly 500 ft. in thickness at the latter place (see Fig. 65), which contain arctic shells, as for example, *Cardium groenlandicum* and *Leda lanceolata*, species unknown from the Scaldisien, or at the earlier horizons of the Red Crag. Until 1896, these deposits had been grouped with the Scaldisien, but in that year I proposed, in consultation with Dr. Lorié, to call them Amstelien.*

Since the deposition of the Lenham Crag and of the sands of Louvain and Diest, the south of England has risen more than 600 ft., the elevatory movement having been gradually less eastwards, in the direction of Belgium. The present elevations of the base of the Pliocene above O.D. are Lenham 600 ft., Cassel 515 ft., Grammont 375 ft., Brussels 235 ft., and Diest 205 ft. (see map, Fig. 64). On the other hand, subsidence has taken place in Holland, regularly increasing northwards towards Amsterdam, where it may have amounted to 1,500 ft. Between the end of the Older Pliocene period and the present day the Anglo-Belgian basin has moved as on a pivot, rising in the south and sinking in the north. The maximum disturbance may have extended along a line drawn from Kent to Amsterdam, dying away to the east and west.

This earth movement may be traced also in East Anglia, and it furnishes us with a clue towards the elucidation of the Pliocene history of that district.†

* *Quart. Journ. Geol. Soc.*, vol. lii, p. 763.

† This subject is more fully dealt with in my paper "On the Pliocene deposits of Holland." *Quart. Journ. Geol. Soc.*, vol. lii, p. 748, 1896.

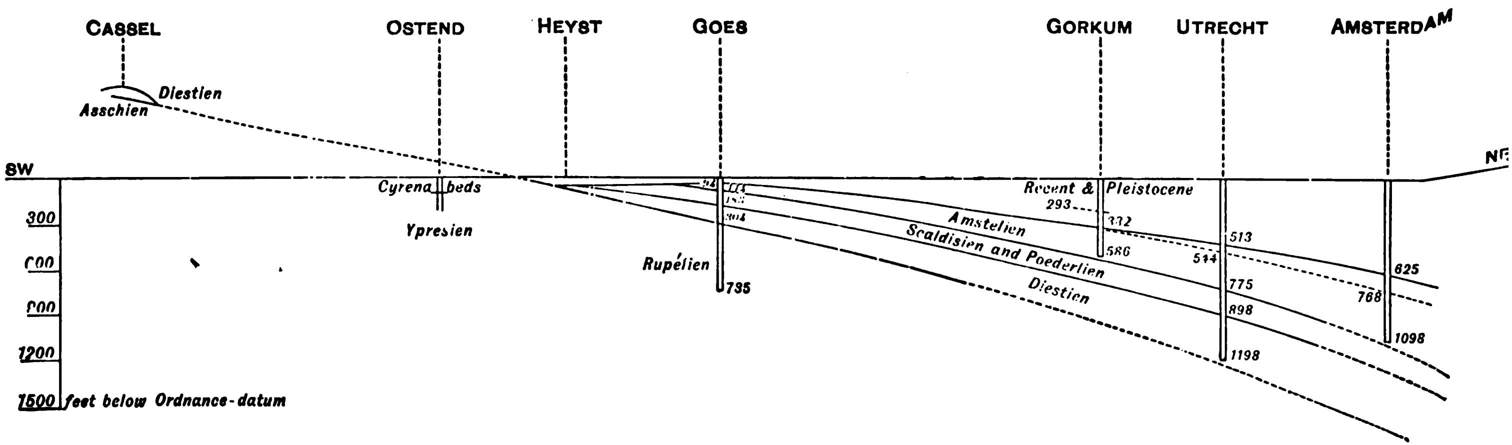


FIG. 65.—SECTION FROM CASSEL TO AMSTERDAM.

(Reproduced, with permission, from Quart. Journ. Geol. Soc., vol. lii, p. 761.)

The beds shown in the above section as Diestien in the borings at Utrecht and Goes, are those which M. Vanden Broeck now calls Casterlien (*Zone à Isocardia cor.*). Those of Cassel are Diestien (*Zone à Terebratula grandis*). If the latter are present at Utrecht, it is at a still lower level.

THE NEWER PLIOCENE DEPOSITS OF EAST ANGLIA.

The Coralline Crag. Gedgravian.

I have recently given my reasons* for disagreeing with many of the conclusions reached in Prestwich's well-known memoir on the Coralline Crag, and especially with his division of this formation into eight zones, characterised by important changes in the physical and climatal conditions of the period, as for example that, at one stage, floating ice may have existed in the North Sea, and that at another, that sea may have attained a depth of 1,000 ft. in the Suffolk area.† Such a depression would have submerged a large part of the East of England, of which there is no evidence, and which seems most improbable. The view taken by S. V. Wood, Junr., and myself, that the fossiliferous sands of the lower part of the Coralline Crag should be separated from the indurated ferruginous rock of the upper portion‡ is also untenable in the light of our present knowledge. The latter beds are merely an altered condition of the former.

As pointed out by Mr. P. F. Kendall§, shells composed of aragonite, a group including most of the Crag Mollusca, have been removed from the decalcified part of the Coralline Crag by the infiltration of water containing carbonic acid, while the calcite shells, as for example, *Pecten* and *Terebratula*, with Echinoderma and Polyzoa, have been preserved. With the exception of the nodule bed at its base, the Coralline Crag is, I believe, one deposit, representing one or more of a series of submarine banks which formerly fringed the western margin of the North Sea, at no great distance from it, in a similar position to those now existing along the eastern coasts of Norfolk and Suffolk (fig. 64).

The southern facies of the molluscan fauna of the Anglo-Belgian basin not only during the deposition of the Lenham beds, but also of the Coralline Crag,|| and its resemblance to that of the Mediterranean, past or present, points, I think, to the conclusion that the Crag area communicated with the Atlantic, up to the end of the latter period, by means of a strait over some part of the south-east of England, possibly as shewn in Fig. 64.¶

If, moreover, the Coralline Crag sea was a basin more or less

* *Quart. Journ. Geol. Soc.*, vol. liv, p. 320. 1898.

† *Quart. Journ. Geol. Soc.*, vol. xxvii, p. 135. 1871.

‡ Supp. to "Mollusca of the Crag," Pal. Soc., p. iii. 1872.

§ *Geol. Mag.*, Dec. ii, vol. x, p. 497. 1883.

|| As to the supposed existence of northern forms in the Coralline Crag see *Quart. Journ. Geol. Soc.*, vol. liv, p. 346. According to my view, the northern species of Mollusca in this formation are only about one per cent. of the whole.

¶ It must not be forgotten that a portion of the south-east of England stood at a much lower level during the Lenham period. The fossiliferous deposits of Gourbesville, near Carentan (*Conglomérat à Terebratules des Bohons, Dollfus, Esq. des Terr. Tert. de la Normandie, Mem. Soc. Géol. de Norm.*, p. 39, 1880) which contain an admixture of Crag species with those of an older type, such as *Terebra basteroti, Mitra aperta*, &c., may be of similar age to the Lenham bed, and indicate the direction in which the Anglo-Belgian basin, in older Pliocene times, communicated with the Atlantic.

ǝed to the north, as seems probable from the absence in it of the eal Mollusca which afterwards invaded the region, the strongest .l currents, those of the flowing tide, would have come from south-west, and not from the north, as at present in the ·th Sea.

Composed almost entirely, as already stated, of organic :erial, the Coralline Crag banks may have originated under the uence of such currents. Where the latter ran strongly no ›osition took place, but shells and shell fragments, swept up n the bottom, would collect in comparatively sheltered itions. Such conditions prevail now in the northern part of Irish Sea, where an accumulation of dead shells on the Turbot .k, off the coast of Antrim, is caused by the tidal currents ch sweep with much velocity through the narrow channel arating Ireland from Scotland. Similar deposits of organic :erial, called by Professor Herdman "neritic," and due to the ›ng currents which run through the Calf sound, exist near the thern extremity of the Isle of Man.

Prestwich attached importance to the occurrence, at certain :es in the Coralline Crag, of layers of large shells, such as *›rina islandica*, which he considered distinctive of special zones t, other beds being characterized by the presence of smaller lls. The species referred to has, however, existed in the North from Miocene times to the present day, possibly without :rmission, so that its presence or absence at any spot must have :n accidental. It is not probable that at one period the ·bottom of the North Sea was for some miles continuously 'ered with a layer of the dead and drifted shells of *Cyprina* l other large Mollusca, and that these species then disappeared a time from the Crag area. Shells are sorted out by currents varying strength as pebbles are in beds of gravel; small cimens would therefore have accumulated in one place, larger :s in another, and comminuted shells, or fine calcareous sand ı third.

We can understand, moreover, on this view, that when, by a ›porary and local diversion of the currents, no sediment ; for a time deposited on any part of the Coralline Crag ›ks, they would have become occupied by colonies of reef-ilding Polyzoa, which flourish best in clear water agitated by 'rents; but such colonies would have been smothered and ıble to exist when another alteration of the current brought over m quantities of the fine mud. Crustaceans and echinoderms ıld, however, have lived on the Crag banks, and here and there a · Mollusca might have established themselves, but their numbers uld have been small in proportion to the drifted shells, as present on the Turbot Bank. There is no evidence of an listurbed sea bottom, still less of deep sea conditions, as sug-ted by Prestwich, uninfluenced by currents, in any part of the

FIG. 66.—MAP OF THE MAIN MASS OF THE CORALLINE CRAG.
(Reproduced, with permission, from Quart. Journ. Geol. Soc., vol. liv, p. 326.)

Note.—The position of pit 30 should have been indicated just below the letter K (in 'Kiln'), due west of Aldeburgh.

oralline Crag. With the few and the local exceptions just ientioned, its fossil Mollusca are those of dead and drifted rganisms. That definite and persistent zones should exist in a

and bank, composed of constantly shifting materials, seems mprobable. No serious attempt has been made to work out tratigraphically the proposed divisions.

For the convenience of members of the Association hereafter visiting the Coralline Crag of the Orford and Aldeburgh districts, the map, Fig. 66, showing the position of the more interesting sections, is reproduced.

The fossiliferous sands may be best studied from Orford, where there is a comfortable inn, the Crown and Castle. A visit to pits 11 and 12 is recommended for the collection of Mollusca. Pits 14 and 18 show the Crag in its decalcified condition, and contain many Polyzoa. In pit 19, the superposition of the Red to the Coralline Crag may be seen.

Aldeburgh is a good centre for the study of the indurated Crag. From pits 30 and 33, many species of Polyzoa may be obtained; 31 contains a layer of the casts of the large aragonite species, *Cardium decorticatum*, *Panopæa faujasii*, *Voluta lamberti*, and others, the calcareous matter of the shells having been completely removed. At Iken, in pit 27, there is an interesting exposure showing a small lenticular mass of the unaltered shelly Crag, in the midst of the ferruginous rock. As the fossils it contains, *Cyprina*, *Cardium*, *Venus*, *Cardita*, &c., can be obtained in large quantities at Sudbourne and Orford, it is earnestly requested that this important and absolutely unique section, of which a photograph is here given (Fig. 67), may remain untouched. Many specimens of Polyzoa and Echinoderma can be found in pit 24 at Iken.

Sutton, some miles to the south-west, is a good locality for both Coralline and Red Crag fossils. Most of S. V. Wood's specimens came from that place.

Some borings I have recently made in the Coralline Crag show that the surface of the London Clay, upon which it rests, dips rather rapidly, from 8 to 10 feet per mile, towards the north-north-east. This must be borne in mind when comparing one section with another. The bed with large shells at pit 11, for example, seems to be on the same level as that containing similar fossils at pit 12, but this is not the case, as between the two places the base of the Crag dips eight or nine feet (Fig. 68).

The larger proportion of the Mollusca known from the Coralline Crag are exceedingly rare in that formation, a number of them having been known to Searles V. Wood from unique, or at the most, from very few specimens only. A consideration of a list of its more abundant and characteristic species brings out clearly two points; the preponderatingly southern character of the fauna, and its close relation to that of the Waltonian zone.

The Red Crag. Waltonian, Newbournian, Butleyan.

The term Red Crag, including, as it does, beds having a widely different fauna, and probably differing, as it seems to me, considerably in age is vague, and when we attempt to correlate the East Anglian deposits with those of other countries, incon-

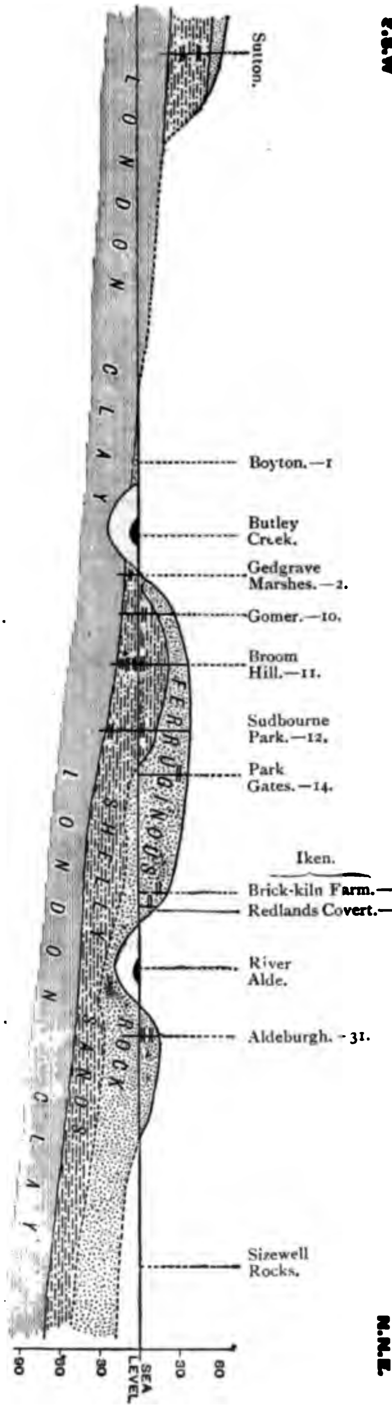


FIG. 68.—SECTION SHOWING THE STRUCTURE OF THE CORALLINE CRAG (ACCORDING TO THE PRESENT WRITER) AND THE PROGRESSIVE DIP OF ITS JUNCTION WITH THE LONDON CLAY TOWARDS THE N.N.E.

(Reproduced, with permission, from Quart. Journ. Geol. Soc., vol. liv, p. 328.)

[The thick straight bars = indicate the position of the seams of large shells. The more recent beds are omitted.]

venient. The Scaldisien of Belgium, with its southern shells, may represent one part of it (the Walton Crag), and the Amstelien of Holland, in which arctic species are common, another. It seems desirable, therefore, while retaining it for general use, to adopt for its various horizons some more definite and distinctive names.

The following classification of the Pliocene strata is that proposed by me in 1900,* except that in deference to the opinion of my friend, Mr. H. B. Woodward, I have now grouped the Norwich, Chillesford, and Weybourne horizons as Icenian.†

The view taken by Prestwich that all the Red Crag deposits are of the same age appears, at first sight, not unreasonable, though it is not so easy to understand why those of the Norwich Crag should have been grouped with them. As to the former, many of their characteristic Mollusca occur in every part of the formation, so that lists of fossils from different localities present more or less resemblance.‡ Such species, however, are not equally common everywhere; some of them seem to have been dying out at certain horizons, while others, generally recent or northern, were appearing for the first time, or becoming more abundant. The zones of the Red Crag arrange themselves in horizontal, and not in vertical sequence, assuming a more recent and a more boreal character as we trace them towards the north; the beds I have classed as Waltonian, Newbournian, and Butleyan, each possessing a distinctive fauna of its own, do not overlap. Taking, for example, the three cliff sections of Walton, Felixstowe, and Bawdsey (fig. 69), at each of which the whole thickness of the Red Crag is, or has been, exposed to its junction with the London Clay, we find no Waltonian deposits underlying the Newbournian at Felixstowe, nor Newbournian below the Butleyan at Bawdsey. Similarly, the Norwich Crag is not known to rest on the Red Crag. The former has been pierced in borings at Beccles and Southwold and found to be, at those places, 80 ft. and 147 ft. in thickness respectively, but the fossils obtained were throughout of the usual Norwich Crag type.§

At the close of the Gedgravian (Coralline Crag) period, an elevation of the Crag area took place, causing some denudation of the shelly sands, apparently greatest towards the south, as the outliers of Coralline Crag in that direction are small, and probably fragmentary.|| The basement bed of the formation, consisting of chalk flints, box-stones, phosphatic nodules, and other

* *Quart. Journ. Geol. Soc.* vol. lvi, p. 708.

† The term Icenian was originally proposed for the Pliocene strata by S. P. Woodward, "Manual of the Mollusca," 1856, p. 400.

‡ As will be seen further on, p. 438, this argument might with equal justice be used to prove an identity between the Coralline Crag, and that of Walton.

§ A recent boring at Lowestoft, for the particulars of which I am indebted to Mr. Whitaker, shows 170 ft. of Chillesford Beds and Norwich Crag, on London Clay, under about 70 ft. of drift. The Chalk was reached at 475 ft.

|| If the Coralline Crag originated as a series of submarine banks, however, it may never have covered a considerable area with a continuous sheet, as formerly supposed.

PROPOSED CLASSIFICATION OF THE PLIOCENE DEPOSITS OF THE EAST OF ENGLAND.

NEWER PLIOCENE.

CROMERIAN	So-called Forest-bed of the Cromer and Kessingland Coasts. Zone of *Elephas meridionalis*. Estuarine and freshwater.			
ICENIAN.	Weybourne and Belaugh Crag. Zone of *Tellina balthica*. Marine.			
	Chillesford beds. Zone of *Leda oblongoides*. Estuarine.			
	Norwich Crag Marine.	Upper division— Zone of *Astarte borealis*. Lower division— Zone of *Mactra subtruncata*.		
BUTLEYAN.	Butley and Bawdsey Crag. Zone of *Cardium groenlandicum*.		Red Crag Marine.	Amstelien, Upper portion.
NEWBOURNIAN.	Newbourn and Sutton Crag. Zone of *Mactra constricta*.			Lower portion.
WALTONIAN.	Essex Crag.	Oakley horizon. Zone of *Mactra obtruncata*.		Poederlien.
		Walton horizon. Zone of *Neptunea contraria*.		Scaldisien.
GEDGRAVIAN.	Coralline Crag. Zone of *Mactra triangula*.			Casterlien.

OLDER PLIOCENE.

bed, 25 in number, only one is not known living, while of the Crag species, 24 out of 32 are extinct. Some of the Crag fossils are Eocene, and therefore clearly derivative; but there is no more evidence for the existence of ***Mastodon*** in East Anglia in the Newer Pliocene period than of *Coryphodon* or *Hyracotherium*.*

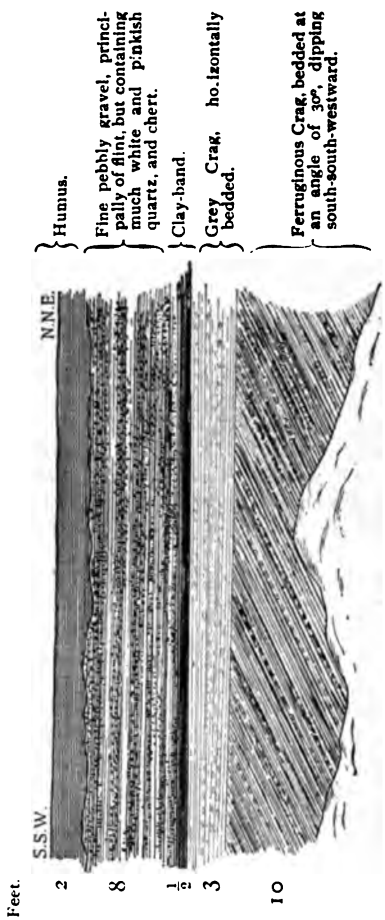


FIG. 70.—SECTION AT WALTON CLIFF.
(*Reproduced, with permission, from Quart Journ. Geol. Soc., vol. lvi, p. 711.*)

Mr. E. T. Newton estimates the percentage of living vertebrates in the nodule beds at 8.8 per cent., and in the Forest-bed at 69.2 per cent.,† too great a difference, I think, to be explained on any other theory than that the fossil remains of the former are principally derivative.

The Red Crag deposits rest against, rather than upon the Coralline Crag. There is a well-known case at Sutton where a colony of *Mytili* is shown to have attached themselves, in Red Crag times, to an old shore line of Coralline Crag, possibly within tide marks. The Coralline Crag outlier of Sutton, together with the principal mass of the formation extending from Gedgrave to Aldeburgh, seem to have formed islands in the Red Crag sea. We have consequently a datum line, twelve miles in length from south-west to north-east, by which we may fix, with some approach to accuracy, the depth of the water in which the Red Crag originated.

* As to the alleged discovery of a skeleton of the Mastodon in the Norwich Crag at Horstead, see *Quart. Jour. Geol. Soc.*, vol. lvi, p. 729. Mr. H. B. Woodward, however, does not agree with the view there taken, see "Geology of Country around Norwich," Mem. Geol. Survey, 1881, p. 57.

† Vertebrata of the Plioc. Dep. of Britain, p. 121, 1891.

Much of the Red Crag is bedded at a continuous angle of about 30°, as, for example, in the cliff section at Walton-on-the-Naze (fig. 70). Such stratification, of an entirely different character to the usual current bedding of the Coralline Crag, indicates, as pointed out by S. V. Wood, Jun., in 1864,* a deposit formed against a beach, or foreshore, or the edges of a shoal.

The frequent south-south-westerly dip of the highly inclined laminæ, as in the above case, shows, however, that the Red Crag was not wholly accumulated against the southern shore of a sea gradually retreating towards the north and the east, or the dip would have been prevalently in the other direction, viz., to the north-east. The tectonic movement which affected East Anglia must therefore have taken the form, not so much of continuous subsidence in one direction, and upheaval in another, as of a succession of foldings which shifted the area of deposition from time to time towards the north or north-east. In this way a series of land-locked bays were formed, one after the other, which were successively silted up by sediment, deposited partly against the shore, and partly as banks or shoals in shallow water. Under such circumstances, the shelly beds so formed would dip in different directions on the opposite sides of the bays.

There is an area immediately to the south of the Hook of Holland, which seems to represent the condition of East Anglia during the Red Crag period. What was formerly a bay or inlet is now nearly choked with shelly sand, which is still accumulating on the edges of the shoals, in channels formerly occupied by the River Maas, often bedded at a high angle, the stratification dipping in different directions as it follows the sinuous winding of the banks.

The position which these bays of the Red Crag period successively occupied may be approximately defined. A reference to the map (fig. 69) will show what I consider to be the geographical divisions of the Crag, as indicated by the differing character of their molluscan fauna.†

One difficulty in working out the Crag history perplexed me for many years, and it is only recently that a probable explanation has suggested itself.

At present dead shells are but seldom met with on the eastern shores of Norfolk and Suffolk. One may walk for a mile along the beach at Yarmouth, or Lowestoft, without finding more than a chance specimen. That this is not due to any absence of molluscan life from the adjoining sea, my son, Dr. Sidney F. Harmer, and I have proved by dredging.

During a visit in 1899 to Hyères, in the south of France, I noticed that of the two low sandy beaches fringing the isthmus which connects the peninsula of Giens with the mainland (fig. 71),

* *Ann. and Mag. of Nat. Hist.*, March, 1864.
† The fauna of the Red Crag District, lying between the rivers Stour and Orwell, has not at present been worked out carefully.

that to the west, several miles in length, was covered from end to end with the shells of dead molluscs, while upon the beach facing the east not a single shell was to be found. The reason for this was obvious; the N.W. mistral was blowing upon the former,

(Reproduced, with permission, from Quart. Journ. Geol. Soc., vol. lvii, p. 407.)

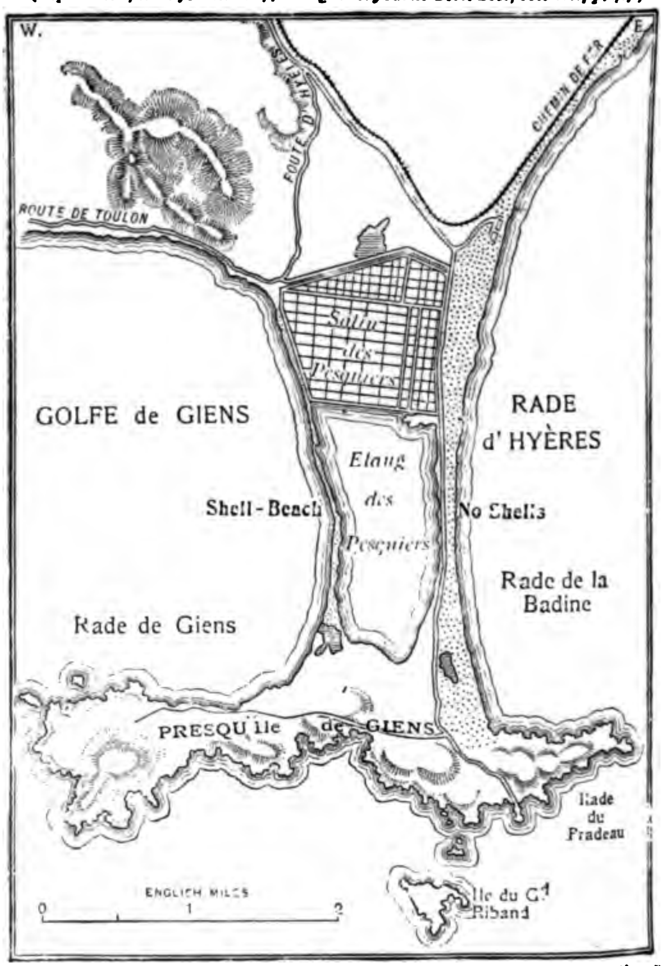


FIG. 71.—MAP OF THE LOW ISTHMUS CONNECTING THE PRESQU'ÎLE DE GIENS WITH THE MAINLAND.

causing considerable surf, while upon the other, protected as it was by the isthmus, the water was perfectly calm.

The sea is agitated during storms to a greater or less depth.

according to their violence, and the size of the waves they cause. Mollusca are at such times rooted up from their usual habitats. Being moved along the bottom in the direction towards which the wind is blowing, they finally accumulate on the opposing beach. At present most of the winter storms prevalent in East Anglia are attended by westerly winds, as the centres of the cyclonic disturbances, approaching our shores from the Atlantic, to which they are due, pass away to the north or north-west of Great Britain. The shell beaches of the British Isles principally occur therefore on our west coasts. Enormous quantities of dead molluscs are blown, however, towards the shores of Holland. Shells lie, in fact, as thickly on the beaches and in the estuarine inlets of the Dutch coast as they did on those of East Anglia during the Red Crag period.* Easterly rather than westerly gales must, therefore, have then been prevalent in the Crag area. I have endeavoured to show elsewhere, by a study of the Meteorology of the later Pliocene epoch, that this may have been the case, the prevalent storm tracks then lying further to the south.†

It is not difficult to understand, when standing on the cliff at Dovercourt, looking out to sea over the bay formed by the projecting headlands of Walton-on-the-Naze on one side, and of Felixstowe on the other, that it would need only the prevalence of strong easterly winds to reproduce there the conditions of the Red Crag period. Were the direction of the winter gales which now drive vast quantities of sand and dead shells on to the shores of Holland, turned towards Essex, the mud flats of Dovercourt Bay would soon become silted up with shelly sand, as was that of the Waltonian region at a former period.

The Coralline Crag has been hitherto referred to the Older, and the Red Crag, including the Walton zone, to the Newer Pliocene, the former being regarded as equivalent to the Piacenziano of Italy.‡

At the time of the publication of Wood's "Supplement to the Mollusca of the Crag," there seemed good reason for this classification, more than half of the Coralline Crag species not being then known from the Red, but a large number of them have since been found by Mr. P. F. Kendall, at Walton, and by myself at Little Oakley, a new and somewhat more recent zone of the Waltonian Crag. An inspection of a list of Coralline

* I noticed two powerful steam dredgers at work in an old channel of the River Maas, now nearly silted up, which raise, I was informed, 100,000 tons of dead shells per annum. Enormous quantities of shells are also collected from the Dutch beaches for lime burning.

† "The Influence of the Winds upon Climate during the Pleistocene Epoch," *Quart. Journ. Geol. Soc.*, vol. lvii, p. 405, 1901.

‡ I have had many opportunities during recent years of studying the deposits of the south of Europe regarded by French and Italian geologists as Older Pliocene, and have formed a strong opinion that, even allowing for difference of latitude, they are older than any part of the East Anglian Crag.

Crag species shows that with the exception of a few small or tender shells, whose absence from a beach deposit may be easily accounted for, almost all the most abundant and characteristic Mollusca of the Coralline Crag have now been found in the Waltonian, as have been also the greater part of its Polyzoa.

The Walton Crag, however, contains certain species unknown from the Coralline, notably the sinistral whelk, *Trophon* (*Neptunea*) *contrarius*, and some others, as,

Nassa propinqua,	*Trochus tumidus*,
* ,, *elegans*,	*Conovulus pyramidalis*,
* ,, *reticosa*,	* *Nucula lævigata*,
Purpura lapillus,	*Cardium parkinsoni*,
,, *tetragona*,	* *Astarte sulcata*,
Bela turricula,	* ,, *obliquata*,
Lacuna subaperta,	,, *compressa*,
Eulimene pendula,	*Venus fasciata*,
Eulimene terebellata,	*Tellina prætenuis*,
* *Natica hemiclausa*,	*Corbulomya complanata*,
Trochus noduliferens,	*Pholas crispata*,
* ,, *cineroides*,	,, *cylindrica*,
,, *subexcavatus*,	

of these, however, those marked * are known to have been living in the North Sea in Diestien or Casterlien times.

None of these are modified descendants of Coralline Crag species. Some may therefore have been immigrants from an outside region, their appearance at this stage having been due to the more or less sudden opening up, by the tectonic movements before alluded to, of communication with northern seas.* At the somewhat later period of the Little Oakley deposit, other immigrants, including some arctic species, arrived in the Crag basin from seas still further north. Neither at the Walton nor the Oakley stage, however, had sufficient time elapsed to allow for the extinction of the greater part of the characteristic Mollusca of the Coralline Crag—that took place later—although some of these were less abundant in the Waltonian than in the Gedgravian Sea.

While, therefore, the Coralline Crag is clearly marked off from that of Walton, as a distinct zone, by the physical changes and by the additions to the fauna alluded to, it seems nearly related to it, sufficiently so, I think, to warrant our regarding the former as Newer Pliocene, the oldest member of a more or less continuous and closely connected series.

* An interesting proof that the Red Crag sea extended to the north of East Anglia is afforded by the fact that some of the characteristic fossils of that deposit, such as *Voluta lamberti*, *Nassa reticosa*, *Trophon costifer*, *Turritella incrassata*, *Astarte mutabilis*, and others, have been found in glacial gravels in Aberdeenshire, no doubt derivative from Crag beds formerly existing in the bed of the North Sea, at no great distance from the coast. *Quart. Journ. Geol. Soc.*, vol. xxxvii, p. 155, 1882.

The distinction between the Lenham beds and the Coralline Crag, is of much greater importance. The former, with the other deposits referred to in an earlier part of this paper, may still be grouped as Older Pliocene. The division between the Older and the Newer Pliocene should therefore, I consider, be drawn between Lenham and the Coralline Crag, rather than between the latter and the Waltonian.

The principal exposures of the Waltonian Crag are, first, those of the cliff section at Walton, next, a small outlier at Beaumont, described 50 years ago by the late John Brown of Stanway,* and last, that of Little Oakley and Ramsey, mid-way between Beaumont and Harwich (fig. 72). The fauna of a pit near Foulton Hall at Little Oakley has proved to be exceedingly rich. From a seam about 2 ft. in thickness, and 10 or 12 yards only in length, I have succeeded in obtaining more than 500 species and well-marked varieties of Mollusca, Polyzoa, &c.,† some of them new to the Crag or to science.

The molluscan fauna of Beaumont is nearly, but not quite, identical with that of Walton, belonging possibly to a slightly newer stage. That of Little Oakley is decidedly more recent, although distinctly Waltonian. It contains all the characteristic and common southern and extinct Mollusca of the Walton zone, but in addition, a number of northern species which either had not penetrated so far south at the Walton period, or are very rarely found in the Crag at that place.

Among these may be mentioned :

Trophon (*Neptunea*) *antiquus*, (the dextral form) not very rare,
,, *despectus*, not very rare,
,, *turtoni*,
,, *scalariformis*, common (very rare at Walton).
,, (*Sipho*) *tortuosus*, not very rare,
,, *islandicus*,
,, *norvegicus*,
Bela scalaris,
,, *assimilis*,
,, *pyramidalis*,

* For Brown's list of Beaumont fossils, see *Mem. Geol. Surv. Walton-Naze and Harwick*, p. 14, 1877. I have since added largely to this list.

† The large number of species obtained from Oakley has been, I think, partly due to the method I employed. I used large sieves, from 12 to 18 inches in diameter, made to fit into each other for convenience of packing, fitted with long handles, with wooden sides, and bottoms of copper wire of a mesh from $\frac{1}{4}$ to $\frac{1}{16}$ in. I employed a labourer to excavate and sift the Crag, while I examined the sifted stuff. We passed it first through a coarse sieve, and afterwards through a finer one, so as not to lose the smaller species. Sometimes, when practicable, the material was sifted dry, but more often in water, in a tub borrowed from the adjoining farmyard. The latter process not only removes the sand, but cleans the fossils at the same time. One may easily examine thoroughly in this manner from half a ton to a ton of Crag per day. It is not practicable to adopt this plan everywhere, but where the consent of the owner of the land can be obtained, I can strongly recommend it.

Natica clausa, common (very rare at Walton).
,, *helicoides*,
Pecten islandicus,
Modiola modiolus,
Tellina prætenuis, not rare (very rare at Walton).

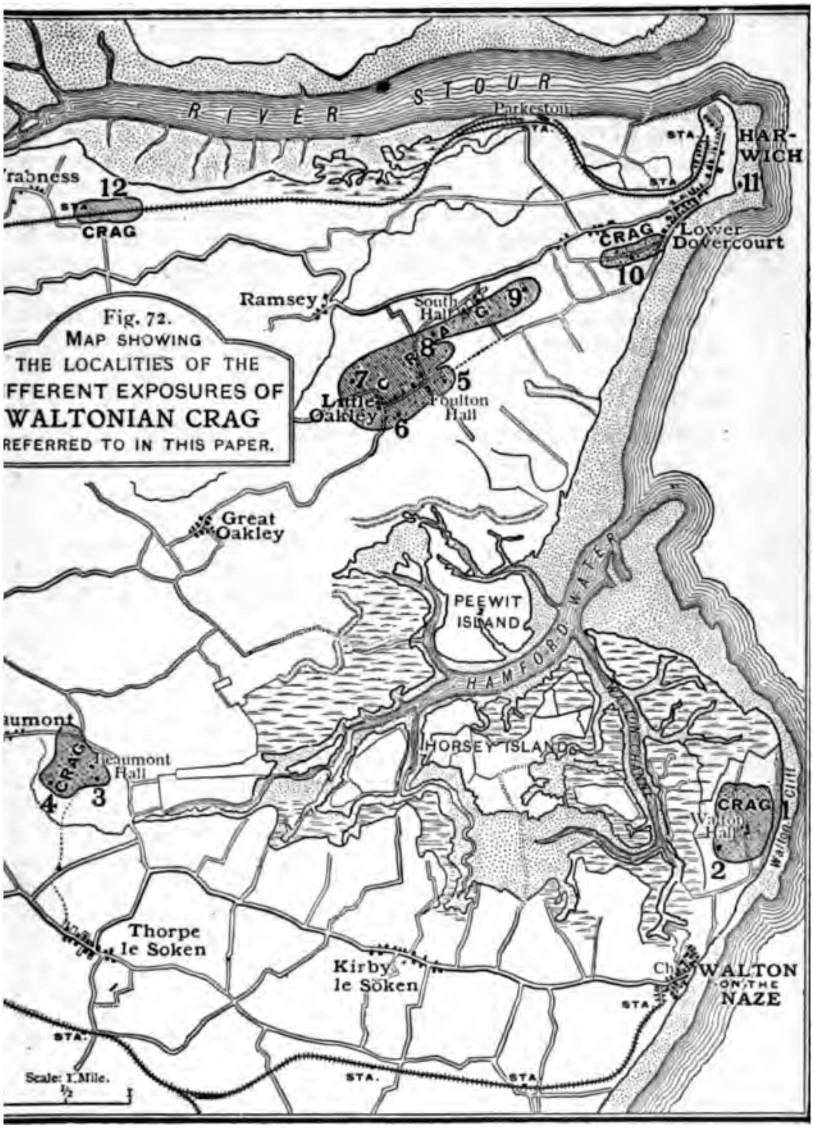
With the exception of those marked otherwise, these species are excessively rare at Oakley. *Tellina prætenuis* is a form not known living, but it probably came in from the north, with the northern shells, and became increasingly abundant with the latter, as did also *Tellina obliqua*, in the North Sea at the later stages of the Crag.

I have given elsewhere my reasons for believing that the sinistral form of the whelk alluded to above is not a monstrous variety of the dextral shell, as generally supposed, but, as originally described by Linnæus, a distinct species.* The two migrated southwards separately, the left-handed form arriving first in the Crag basin. *Trophon* (*Neptunea*) *contrarius* is exceedingly common in the Waltonian deposits of England, and in the Scaldisien of Belgium. A closely allied variety, *T. sinistrorsus*, penetrated as far south as the Mediterranean, being found with some other northern species in the latest Pliocene (? Pleistocene) beds of Sicily. A similar shell now lives in Vigo Bay, on the Spanish coast, but it is not known further to the north. *T. contrarius* gradually becomes less abundant in the upper stages of the Red Crag, is exceedingly rare in the Norwich Crag, and is at present unknown in British Seas.† On the contrary, the right-handed group, *T. antiquus*, with its allies *T. despectus*, &c., are almost unknown at Walton and Beaumont; they occur, however, at Oakley, and become more abundant in the later Crag beds as the left-handed shells become less so. *T. antiquus* is one of the characteristic species of the Icenian Crag, and of the various glacial deposits. It still inhabits the North Sea, but it does not range into the Mediterranean, or as far south as the coast of Spain.

The earliest stage of the Red Crag period is thus represented by the Crag of Walton Cliff. The North Sea then extended but little to the west of its present limits. The beds shown in the cliff section at Walton (fig. 70) dipping sharply to the S.S.W. must have been banked against the northern shore of a small bay which did not extend northwards into Suffolk, its southern limit lying farther south. A slight depression caused the deposition of horizontal strata upon the beach Crag, and carried the Waltonian bay inland over the London Clay flats, towards Beaumont (fig. 72). Some alteration in level afterwards enabled the sea to encroach in the direction of Little Oakley and Ramsey,

* *Proc. Inter. Congr. Zool.*, Cambridge, p. 222, 1878.

† The sinistral whelks sometimes found on our coasts are not the Crag form, *T. contrarius*, but reversed specimens of the right-handed form, *T. antiquus*. No reversed (*i.e.*, dextral) specimens of *T. contrarius* have ever been met with.



(*Reproduced, with permission, from Quart. Journ. Geol. Soc., vol. lvi, p. 710.*)

at which time the northern shells had begun to arrive in increased numbers and variety.

Subsequently to this, a more important movement took place which probably laid dry the whole of Essex, and submerged a considerable area in Suffolk.

The region lying to the west of the Deben, together with the well-known Crag localities of Sutton, Shottisham, and Ramsholt, to the east of that river, is covered by Crag, the fauna of which differs in important respects from that of the Waltonian region (fig. 69). For this stage, I have proposed the term Newbournian. To S. V. Wood it was known as the Sutton Crag, but as Sutton is a Coralline Crag locality also, Newbournian may perhaps be preferable.

In these beds some of the most characteristic Waltonian forms are less numerous; while other species are appearing for the first time, or increasing in abundance. Of the latter may be mentioned:

Trophon (*Neptunea*) *antiquus*,
Cancellaria viridula,
Scalaria groenlandica,
Natica helicoides,

Modiola modiolus,
Nucula cobboldiæ,
Leda oblongoides,
Cardium angustatum,
Astarte compressa,
,, *sulcata*,
Tellina obliqua,
,, *prætenuis*,
Mactra ovalis,
,, *constricta*.

At a subsequent stage (Butleyan), the sea appears to have retired from the part of Suffolk which lies to the west of the Deben, partly perhaps because of a slight elevation of the Newbournian area, and partly because it had become choked with shelly sand, but an inlet came into existence to the west of the island of Coralline Crag of Orford and Aldeburgh. The Crag of Butley and of the Stackyard Pit at Chillesford has been generally regarded as belonging to the latest part of the Red Crag. At the stage represented by these beds a much larger number of the characteristic Walton species had disappeared, or had become rare, while the percentage of northern forms is correspondingly greater. In the Butley zone, *Trophon antiquus* is nearly as abundant as *T. contrarius*. Several species of *Leda* are not infrequent, and *Nucula cobboldiæ* is very common, while *Tellina obliqua*, *T. prætenuis*, *Mactra ovalis*, *M. constricta*, *Cardium angustatum*, with some recent British species, are so abundant as to make up a large proportion of the shells present.

There are other exposures of Crag at Alderton, Hollesley, and Bawdsey, containing a fauna similar to that of Butley, the arctic shell *Cardium groenlandicum*, almost unknown in the Newbournian deposits, being especially characteristic of the last-named locality. These, with some other exposures in the same neighbourhood, I have grouped as Butleyan, a division which contains a more recent, as well as a more boreal fauna than that of the zones before mentioned.

The distinction between the Butleyan and Newbournian zones seems to me as strongly marked as that between the other divisions of the Red Crag, or even that between the Coralline and the Waltonian. (See analysis of molluscan fauna, p. 448.)

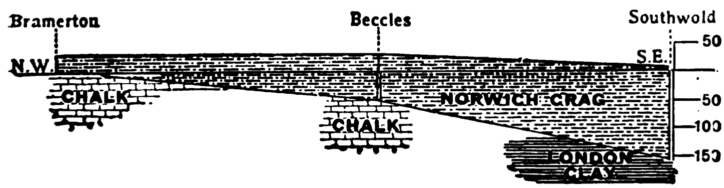
THE NORWICH, CHILLESFORD, AND WEYBOURN CRAGS.

Icenian.

These beds differ widely from those of the Red Crag, and are, I consider, considerably newer.

The latter never attain any great thickness, generally not more

FIG. 73.—SECTION FROM BRAMERTON, NEAR NORWICH, TO SOUTHWOLD.



[The Glacial deposits are omitted.]

(Reproduced, with permission, from Quart. Journ. Geol. Soc., vol. lvi, p. 734.)

than about 20 ft., and constantly present the highly inclined bedding, as of a beach, shown in fig. 70.

The Norwich Crag on the contrary is never beach-bedded nor is it so uniformly fossiliferous as are the unaltered beds of the Red Crag. It occupies, moreover, a different area, coming in first immediately to the north of Aldeburgh, from which place it thickens rapidly northwards, as shown in fig. 74.

Similarly it thickens also from W. to E. (fig. 73), that is, in the direction of Amsterdam, where the Pliocene and more recent deposits are probably 1,500 ft. in thickness (fig. 75).

The conditions under which the Norwich Crag originated were, I think, different to those obtaining in East Anglia during the deposition of the Red Crag. It seems not improbable that the former represents the western edge of the great delta formation of the Rhine and its affluents. In the East Anglian area occupied by the Norwich Crag, equally with that of Holland, gradual

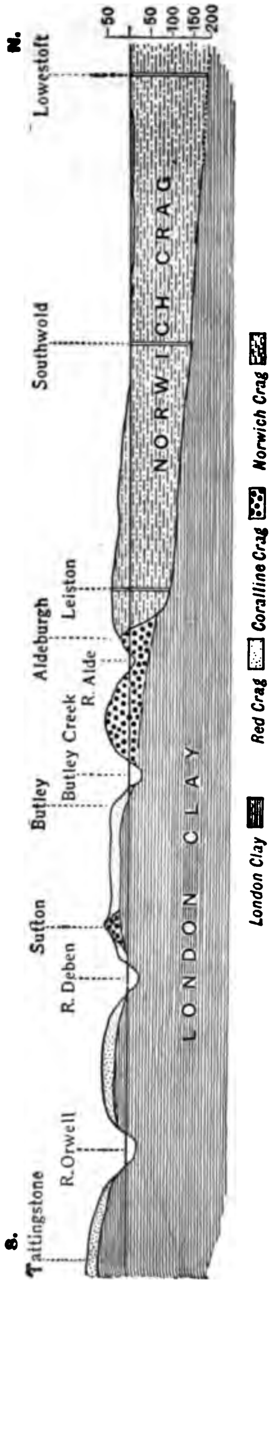


FIG. 74.—SECTION FROM TATTINGSTONE TO LOWESTOFT, SHOWING THE COMPARATIVE THICKNESS OF THE RED CRAG, AND OF THE NORWICH CRAG OF EAST SUFFOLK, AS ALSO THE RAPID THICKENING OF THE LATTER NORTHWARD.
[The Glacial deposits are omitted.]

(Reproduced, with permission, from Quart. Journ. Geol. Soc., vol. lvi, p. 734.)

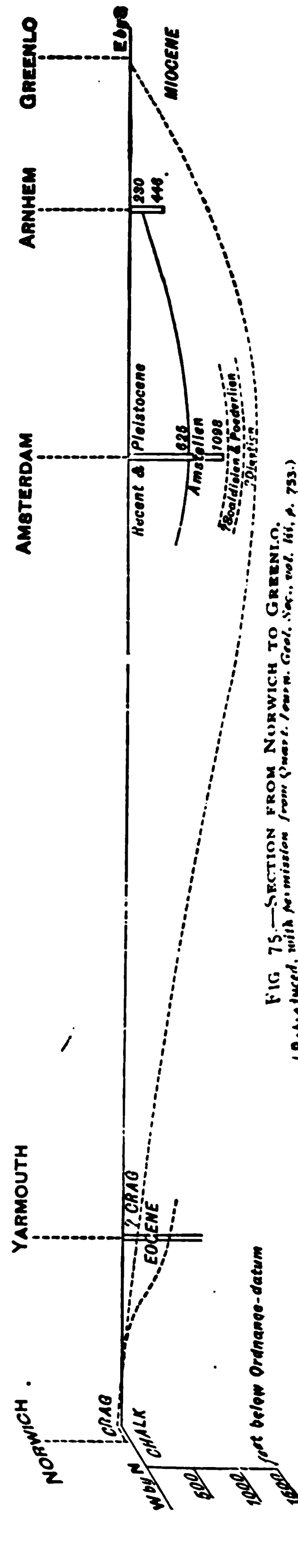


FIG. 75.—SECTION FROM NORWICH TO GREENLO.
(Reproduced, with permission, from Quart. Journ. Geol. Soc., vol. lii, p. 753.)

: was going on, *pari passu*, with the deposition of
The shells found in the boring at Southwold, where
is 147 ft. in thickness, for example, are throughout of
and shallow water Norwich Crag type.

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FIG. 76.—MAP SHEWING THE PRINCIPAL EXPOSURES OF THE CHILLESFORD CLAY (+) AND THE PROBABLE COURSE OF ONE OF THE ESTUARIES OF THE RHINE AT THE CHILLESFORD STAGE. (THE DOTTED AREA INDICATES APPROXIMATELY THE DISTRIBUTION OF THE PEBBLY GRAVELS.)

at some localities of a few land and fresh water shells,
:he estuarine species *Scrobicularia piperata*, has been
o point to estuarine conditions at this period. The
d area which these deposits cover, and their great
in places, seem, however, opposed to such a view

(fig. 69). I am inclined to regard them as marine though accumulated near the mouth of some river, which was possibly one of the tributaries of the Rhine.

The general character of the Norwich Crag fauna is similar throughout the whole area covered by it; the only palæontological difference by which its various exposures can be distinguished being that the arctic species *Astarte borealis* is found only in the northern part, being abundant at Norwich, and in the Bure valley, less so in the north of Suffolk, and unknown further south, as at Southwold, Dunwich, Bulchamp, and Aldeburgh. The Crag of the region characterized by the presence of this shell, one of the latest of the northern immigrants, may therefore be somewhat more recent than that from which it is absent, a view in accordance with the theory of a gradual and continued submergence towards the north. Not more than forty species of Mollusca are really common in the Norwich Crag, the most abundant being the following; about three-fourths of them are recent, and nearly two-thirds characteristic North Sea forms at the present day.

Buccinum undatum,
Purpura lapillus,
Trophon (*Neptunea*) *antiquus*,
Cerithium tricinctum,
Turritella incrassata,
,, *terebra*,
Littorina litorea,
Natica catena,
Pecten opercularis,
Nucula cobboldiæ,
Leda oblongoides,
Lucina borealis,
Cardium edule,
Astarte borealis,
,, *compressa*,
Cyprina islandica,
Tellina lata,
,, *obliqua*,
,, *prætenuis*,
Mactra ovalis,
,, *subtruncata*,
Mya arenaria,
,, *truncata*.

The Chillesford Clay is, I consider, an estuarine deposit. It may be traced through East Suffolk from Orford and Aldeburgh northwards, along a somewhat sinuous line, as shown on the map (fig. 76), as far as Beccles, and thence into Norfolk to Brundall, and to Wroxham, Coltishall, and Burgh, in the Bure valley. At the two last-named places it rests upon fossiliferous sands containing the usual Norwich Crag Mollusca. Further to the north it is difficult to trace. Beds of laminated clay exist in that direction, but they may or may not belong to this horizon. The Chillesford Clay seems only to retain its usual character in that part of the area, where the typical deposits of the Norwich zone are present.

To the north of Burgh, the Norwich horizon of the Crag beds also disappears, with the laminated clays which can be, with more or less certainty, identified with the Chillesford zone. I have elsewhere suggested that the estuarine Chillesford Clay epresents one of the channels by which the Rhine reached the ea,* as do also the estuarine gravels and clays of the somewhat ater Forest-bed (so called) of the Cromer and Lowestoft coasts. :f so, the Chillesford Clay estuary must have opened to the ea northwards. If my view of the origin of the Norwich Crag is orrect, that deposit must also have formerly extended over orth-east Norfolk, all traces of it in that region having been emoved by subsequent denudation.

Immediately underlying the Chillesford Clay in the pit behind Chillesford Church is a fossiliferous sand containing a molluscan auna of a somewhat different character to that which is so persistent in beds of the usual Norwich Crag type over an area forty niles in length. There is no other deposit at present exposed vhere precisely the same group of shells is found.† The most characteristic of these are:

Turritella terebra,	*Cardium edule,*
Natica catena,	,, *groenlandicum,*
Leda oblongoides,	*Mactra ovalis,*
,, *lanceolata,*	*Tellina lata,*
Nucula cobboldiæ,	,, *obliqua,*
,, *tenuis,*	*Mya truncata.*

Many of the bivalves occur with both valves adherent, but not pecially in the position of growth. The deposit does not wholly epresent an undisturbed sea-bottom; most of the shells appear to ave been drifted, and may have been brought up by the scour of he estuarine tides, having been buried while living, or soon after leath, in the tidal sediment.‡

The fossils of the Chillesford Church pit are in a decayed ondition, resembling those found in freshwater strata, and ontrast strongly with the better preserved shells of the marine Crag.§ Mr. J. Lomas states that, when examined under the nicroscope, the grains of the sand in which these fossils occur are een to be less rounded than those of the beach sands of the Red Crag.‖

The Chillesford Clay is specially characterized by the contant presence of minute flakes of mica, derived, it may be, from ne Devonian Schists of the Ardennes, or possibly, as suggested y the Cav. W. P. Jervis, from micaceous rocks further to the outh.¶ Mica is also common in many of the Dutch deposits.

* *Quart. Journ. Geol. Soc.*, vol. lii, p. 770, 1896.

† The Crag of the Stackyard pit of Chillesford, at a considerably lower level than the hurch pit, belongs, as before stated, to the Butleyan zone of the Red Crag.

‡ The Rev. O. Fisher, however, describes a bed of *Mya truncata* in the position of owth at the base of the Chillesford section, which is not always visible.

§ There is a similar difference in the condition of the shells dredged in Strangford ough, an extensive sheet of water communicating with the Irish Sea by an exceedingly arrow channel, and of those met with in the open sea outside.—*Rep. Brit. Assn.*, *ublin*, p. 110, 1857.

‖ *Quart. Jour. Geol Soc.*, vol. lvi, p. 724, 1900.

¶ *Trans. Vict. Inst.*, vol. xxxii, p. 327, 1898-9.

This stage of the Pliocene history was thus marked by a slight elevation, by means of which East Anglia became land, traversed by an arm of the Rhine, the German Ocean having retired somewhat further to the north.

During the Weybourne stage of the Icenian period, however, the Crag Sea again encroached upon the north-eastern corner of Norfolk, penetrating, perhaps, as far south as Norwich. The molluscan fauna of this zone is the poorest, as well as the most recent, of the Crag beds. It comprises not more than 50 species altogether, almost all being common British or northern forms, and is specially characterised by the first appearance and great abundance of *Tellina balthica*, a shell never found at any earlier horizon of the Crag. The sudden appearance of this mollusc at this horizon in such extraordinary profusion, suggests that communication was at that time opened up between the Crag Sea and some area, perhaps the southern part of the Baltic, where it had previously established itself. The *Tellina balthica* Crag is met with at Weybourne and other places on the coast. Beds with a similar fauna occur also inland, as near Aylsham, and at North Walsham, and at Belaugh,* Wroxham, Crostwick, and elsewhere in the Bure valley. The occurrence of *Tellina balthica* is not recorded at any Crag locality to the south of Norwich.

The mutual relationship of the various horizons of the Crag may be summarized as follows :

Analysis of the Molluscan Fauna of the different Horizons of the Crag. (Characteristic and abundant species only.)

	Not known living. per cent.	*Living only in distant seas.* per cent.	*Southern.* per cent.	*Northern.* per cent.	*Northern and Southern.* per cent.
Gedgravian	38	4	26	1	31
Waltonian............	36	4	20	5	35
Newbournian	32	5	16	11	36
Butleyan	13	4	13	23	47
Norwich Zone......	11	—	7	32	50
Weybourn Zone †	11	—	—	33	56

In calculating the various percentages, the more characteristic species of each zone only are taken into account. It is not always easy to draw the line between rare and abundant forms, and possibly the details which might be tabulated by another observer would be somewhat different. I have little doubt however that, in any case, the general results would agree with those here given, and that the foregoing statistics, though they must be regarded as approximate only, justify the conclusions to be drawn from them.

* At Belaugh the *Tellina balthica* Crag has eroded the Norwich Crag and the Chillesford Clay, and rests directly on the Chalk.

† The above figures do not adequately represent the modern character of the Weybournian fauna. If individuals could be counted rather than species, the recent shells would form more than nine-tenths of the whole; the specimens of *Tellina balthica* alone far outnumbering all the others put together.

THE FOREST-BED SERIES.

Cromerian.*

Again the sea retired, and East Anglia became land, as during he Chillesfordian stage, but the estuary of the Rhine lay somewhat further to the east.

Up to this period the fossils of the Pliocene deposits of the East of England indicate a uniform and continuous refrigeration n the climate of that region.

The fauna and flora of the Forest-bed series, on the contrary, eem to point in another direction, presenting the first of those climatal oscillations which, in the opinion of many geologists, were characteristic of the glacial and post-glacial epochs.†

The Forest-bed and its fauna were once supposed to indicate he site and the animal life of a former East Anglian woodland. The tree-stumps, so frequently met with in that deposit, however, lo not occur in place, but have been drifted; the mammalian emains are not found as perfect skeletons, but as isolated and often fragmentary bones or teeth, and may represent the fauna of some part of the Rhine valley towards the south, rather than hat of East Anglia. A possible explanation of the presence of hese fossils in such abundance in the Forest-bed may be that animals browsing in herds on the low grounds bordering the iver were overtaken from time to time by sudden and violent loods and swept down by the current to their present resting place.

During the period represented by the estuarine deposits of he Forest-bed the Rhine seems to have swung round in a great bend from Kessingland to Cromer, following, more or less, the present trend of the coast. It is on the convex banks of a stream, as the river yachtsmen of Norfolk know, that shoals and mud banks accumulate. In such a position was the sediment of the great river deposited, and its wreckage stranded. In this way, I suggest, we may most reasonably explain the great abundance in one small area of tree-stumps, and of the bones and teeth of elephants and other animals.

The general character of the mammalian fauna is distinctly southern. A few specimens of northern forms, such as *Ovibos*, and *Gulo* have been found; those of the southern species *Elephas meridionalis*, the most characteristic of the Forest-bed mammals, are, on the contrary, exceedingly common. This, taken with the fact, stated by Mr. Reid, that the flora of these deposits is similar to

* This is the name adopted by Renevier, *Chronogr. géol.*, 2nd edit., 1896. "Tableau des Terrains sédimentaires."

† I have given elsewhere my reasons for thinking that such oscillations of climate may have been local rather than general. *Quart. Journ. Geol. Soc.*, vol. lvii, pp. 440 *et seq.* 1901.

that of East Anglia at the present day, indicates, I think, that the climate of north-western Europe at this period was not severe.

Associated with the estuarine gravels and clays of the Forest-bed are some fresh water deposits, implying slight changes in the position of the Rhine, and probably in the level of the land. As the river shifted its course eastwards, the mud flats of its former estuary became the site of swamp, morass, or shallow lake, presenting conditions more or less similar to those of the Broadland of the present day.

A bird's-eye view of Norfolk at this period would have been one of low sandy plains covered by woods of spruce or Scotch fir, with groves of beech, oak, or elm, in places, and a tangled undergrowth of bramble, hawthorn, and hazel. On the west, rolling chalk downs; on the east, broads and swamps, filled with aquatic plants such as now grow in the district, and fringed with thickets of alder, willow, and birch. Further to the east lay the great estuary, often swollen and turbid and then sweeping down, with other flotsam and jetsam, the stools of trees, torn from its undermined banks, and, from time to time, the carcases of elephant or deer. Beyond the Rhine, on the opposite shore, a vast plain, now covered by the sea, but then dark with pine forests, stretched eastward to the distant horizon, and thence to Holland.

The plant and animal life of East Anglia at this period was varied and abundant. The Broads and streams, which as at present swarmed with fish—pike, roach, perch and bream—were margined with the water lily, and the water plantain, and with masses of dock, sedge and reed. The marshes were gay with meadow rue and cotton grass, and with buttercups and the golden flowers of the *Caltha*, while here and there arose a great clump of the royal *Osmunda*. Flocks of geese and wild duck, undisturbed by tourist or sportsman, made their home in these inland waters, and in the evening the owl, on noiseless wing, scoured the country in search of its prey. Squirrels scampered through the trees, and frogs croaked in the damp meadows, dotted then as they are to-day, by the rounded hillocks of the mole. From their holes in the river banks, or their lairs in the reed beds, otters issued for their nightly fishing, while beavers were busy in the construction of their dams. Smaller animals, as mice, shrews, and water voles, everywhere abounded, and the poisonous adder lurked in the woods.*

Such was then the aspect of the Pliocene Broadland, presenting, more or less, the features which were in after times to make it famous; but once more the scene changed.

The climate of northern Europe again became colder, and the Great Ice age was soon to hold East Anglia in its wintry grasp. An indication of its approach is afforded by the

* Our knowledge of the flora of the Forest-bed deposits is largely due to Mr. C. Reid.

Leda myalis sands, and the arctic freshwater bed of Mundesley and Beeston, the latter containing the northern plants, *Salix polaris*, *Betula nana*, and *Hypnum turgescens*, and grouped by Mr. Reid with the glacial deposits. No important break seems to exist in East Anglia, however, between the Pliocene and the Pleistocene, and otherwise than locally no satisfactory line can be drawn to separate them. Glacial conditions had probably commenced in Scandinavia during the deposition of the later beds of the English Crag.

PART II.

THE PLEISTOCENE AND RECENT PERIODS.

Although the Glacial deposits of East Anglia have been closely studied for many years, especially by the officers of H.M. Geological Survey, and there is more or less agreement as to their succession and relation to each other, no consensus of opinion has yet been arrived at as to the conditions under which they originated. The subject must sooner or later be dealt with on a larger scale than is at present possible; the East Anglian deposits being considered in connection with those of other parts of Great Britain, and of the Continent (especially of Belgium), as well as with the gravels lying outside the regions actually glaciated, some of which may have been due to torrents issuing from the ice during summer at the period of maximum glaciation.

In a map of the Crag and Drift Beds of south-east Suffolk, published in 1864, S. V. Wood, Jr., first showed the relation of the Chalky Boulder Clay (which he called "the upper or clay drift") to the great sheet of sand and gravel ("lower drift") which underlies it in that region.* During a visit to Norfolk, in the summer of the same year, he ascertained that the Glacial deposits of the Cromer coast belonged to a still older horizon, and in a second map, and a paper printed for private circulation, copies of which he placed in the Library of the Geological Society, he adopted a tripartite division of the Glacial beds.† Such a classification may be of local application only, but, as to East Anglia, the succession proposed by Wood has been more or less generally followed.

The most important development of the deposits called by Wood "Lower Glacial," is to be found in the north-eastern part of Norfolk. The well-known coast section, extending from Hasboro' to Weybourne, has been much studied by geologists and specially by Mr. Clement Reid, whose views on the subject were stated in 1880, in an important paper,‡ and afterwards in his Survey Memoir.§

* *Ann. Mag. Nat. Hist.*, Ser. 3, vol. xiii, pl. xvii.

† "Remarks in explanation of a Map of the Upper Tertiaries of Norfolk, Suffolk, &c." 1865.

‡ *Geol. Mag.*, Dec. ii, vol. vii, p. 55, 1880.

§ *Mem. Geol. Survey*, Cromer, 1882.

THE LOWER GLACIAL DEPOSITS OF EAST ANGLIA.

(a) The Cromer Till, and the Pebbly Series (Westleton Shingle).

The Cromer Till may be conveniently studied at the south-eastern extremity of the Norfolk coast section, near Hasboro', where it rests on the Pliocene beds, and is exposed at the base of the cliff. It consists there of a dirty looking blue clay, rather sandy, hardened, and sometimes pseudo-bedded, apparently by the pressure of ice moving over it. It contains many recent shells, more or less broken, especially *Tellina balthica*, *Cardium edule*, and *Cyprina islandica*, with grey flints, and small striated boulders of hard chalk. Mr. Reid has noted also the presence of red chalk, Kimeridge clay, Lias, New Red sandstone (?), Carboniferous sandstone and chert, and Old Red sandstone, together with igneous rocks—granite, gneiss, and basalt.* The general character of the Till and of its included débris differs, however, in important particulars from that of the Chalky Boulder Clay, the Upper Glacial of Wood. Near Mundesley, the former contains occasionally seams of sand or fine gravel.

Resting on the Till at Hasboro' are some laminated clays and sands, occasionally finely ripple-marked, as if by gently running water. An examination of these by Mr. Reid failed to detect the presence of Entomostraca, or Foraminifera, leading him to the conclusion that they are not of marine origin.

Towards Mundesley, these deposits seem to pass into the stratified sands which in that direction underlie the Contorted Drift; they may represent a temporary or local retreat of the ice foot, during which muddy streams issued from it.

Overlying the laminated beds just mentioned is a deposit of chalky clay of a somewhat similar character to that of Weybourne and Wells (see p. 454), which Mr. Reid describes as a "Second Till," but which Wood regarded as Contorted Drift. Its included boulders are similar to those of the basement Till, but it contains much soft Upper Chalk débris, probably derived from a source nearer at hand than that of the hard Chalk of the latter. As we trace the Glacial Beds westwards towards Mundesley, and beyond, this Upper Boulder Clay appears to pass into the Contorted Drift, which has been in places in that direction much disturbed, more or less contemporaneously, I think, with its deposition; the sands overlying it (probably Middle Glacial) showing there no similar evidence of disturbance.

Both the Till and the Upper Boulder Clay of Hasboro' must

* *Mem. Geol. Surv.*, Cromer, p. 87. 1882.

have been due to ice which was to some extent, at least, fed from the Chalk country to the north-west, but the shelly débris they contain indicates that in approaching Norfolk it travelled, for a part of its course, over the sea bottom.

In order to explain the greater abundance of soft chalk in the Upper Clay, Mr. Reid suggests that the ice, during its first advance, ploughed off many of the shelly sand-banks then resting on the sea bottom, passing during its second advance over the bared surface of the Upper Chalk.*

He remarks, moreover, that some of the included boulders have been bored by annelids, and subsequently striated, pointing to the agency of coast ice for their original introduction into the East Anglian area. In this way, some of the small boulders of rhomb-porphyry which are from time to time picked up on the beach, possibly derived from the cliff, may also have reached us.

Underlying the Norwich Brickearth (to be dealt with later on) to the north of that city, as at Hellesdon, Sprowston, and elsewhere, are some unfossiliferous pebbly gravels, composed almost entirely of flint, sometimes interstratified with sand, which were correlated, but I now think erroneously, by Wood and myself in 1868, with the *Tellina balthica* Crag of Weybourne and Belaugh.† It appeared to me, when mapping the country during the years 1865-1870, that these pebbly gravels might be traced in a south-easterly direction, to Halesworth and Southwold, and thence to Westleton and Dunwich, as shown on the map (fig. 76). Messrs. Whitaker and Dalton, without committing themselves to the Glacial age of these beds, have recognised them as occupying a definite position between the Chillesford Clay and the Glacial deposits,‡ and a similar view was taken by the late Mr. J. H. Blake.§ Mr. H. B. Woodward, however, considers the pebbly gravels of Hellesdon, &c., to be of Crag age, while, with Prestwich, he regards the shingle of Westleton as "Middle Glacial."‖ It is undoubtedly true, as Mr. Woodward points out, that seams of pebbly gravel occur occasionally, both in the Crag and in the Middle Glacial Sands; similarly, we sometimes find on our coasts at the present day that the beach is covered with shingle at one spot, and at another, a mile further on, with sand only. The Pebbly Gravels maintain a persistent character, however, over so large an area, that I still believe, with the geologists just named, that they indicate a distinct horizon, and that they originated under special conditions. The Middle Glacial Sands, although they sometimes contain seams of flint pebbles (possibly in places reconstructed Westleton Shingle), and are largely composed of gravel towards the south, maintain in the region in

* *Loc. cit.*, p. 91.
† *Rep. Brit. Assoc.*, Norwich, p. 83, 1868.
‡ *Mem. Geol. Survey*, Halesworth, p. 11, 1887.
§ *Mem. Geol Survey*, Yarmouth, p. 25, 1890.
‖ *Geol. Mag*, Dec. iv, vol. ix., p. 27, 1902.

question their prevalently sandy character. The Pebble Beds, composed almost entirely of flint, suggest much contemporaneous denudation of the Chalk. They may represent the littoral deposits of a shallow sea of Lower Glacial age, or, possibly, the product of a sub-glacial stream issuing from the chalk country to the north-west, a region that was afterwards to furnish much material for the chalky clays by which at a later stage of its history East Anglia was covered.*

(b) The Contorted Drift, and the Norwich Brickearth.

The area continuously covered by the beds, newer than the Pebbly Gravels, grouped by Wood and myself as Lower Glacial, is situated to the north-east of a line drawn in a south-easterly direction from the eastern limit of sheet 69 (fig. 78) to Corton (between Hopton and Pakefield) on the Suffolk coast. From sheet 69 to the south-eastern corner of 68 S.W., this line roughly divides the area occupied by the Lower Glacial clays, left white on the map, and that of the Chalky Boulder Clay, coloured black, but towards the east, in sheets 66 N.E., and 67, the latter overlaps and overlies the former. The superposition of the one to the other may be there seen in vertical section, as in the cliff at Corton and elsewhere.

Immediately to the north, north-east, and north-west of Norwich, the Lower Glacial deposits are represented, first, as I think, by the pebbly flint gravels already mentioned, and next, by a bed of sandy brickearth, of a dark reddish brown colour, which from the time of the Romans to the present day has been drawn on for building purposes. This seam of brickearth, attaining a thickness of ten feet and upwards in the neighbourhood of that city, thickens out northwards, being overlain in that direction on higher ground by yellow sands (Middle Glacial). Traced eastwards in the direction of Yarmouth, and northwards towards Cromer, Mundesley, or Hasboro', the Norwich Brickearth passes horizontally into the Contorted Drift of the coast.

Towards the north-west, in the direction of Holt and Wells, the Lower Glacial clay consists of an impervious marl, so chalky that it is generally burned for lime in preference to the Chalk itself. This marly condition of the Contorted Drift is well shown in a large excavation near the railway station at Wells. Passing eastwards from Wells, we find the Lower Glacial maintaining a similar character at Weybourne, but as we follow the cliff section towards Cromer, it gradually assumes the contorted condition to which its appropriate name is due. Enormous masses of marl,

* As one approaches Marseilles by train from Tarascon and Arles, the country (the *campus lapideus* of the Romans, and the supposed scene of the combat between Hercules and the Ligurians) is seen to be overspread by a great sheet of gravel, the detritus brought down by the Rhone in Glacial times, which reminds one strongly of the Pebbly Gravels of East Anglia.

similar in character to that of Weybourne and Wells, and of marly chalk, sometimes showing lines of flint *in situ*, are associated with beds of clay, loam, sand, and gravel, the stratification of which has been, over a certain district, constantly disturbed and bent.

The included masses of chalk and marl, and the contortions of the stratified drift tend generally to disappear, however, as we trace the Lower Glacial deposits to the south-east of Cromer. Messrs. H. B. Woodward and C. Reid consider that the contortions were not contemporaneous, but that they were caused at a later stage by the ice to which the Chalky Boulder Clay was due, that ice having then reached the Norfolk area from the north and north-east. The disturbance of the Contorted Drift was no doubt due to the North Sea ice, but partly, at least, I think, at the time of its deposition; partly, possibly, contemporaneously with the maximum extension of the Chalky Boulder Clay glacier; the latter, however, approached East Anglia, as I shall endeavour to explain later on, from the north-west,* and did not ever reach the Cromer coast.

The Lower Glacial Brickearth (the Contorted Drift in its uncontorted form) may be traced continuously from Norwich over the region lying to the north-east of the River Yare, and thence, as just stated, into Sheet 67 (fig. 78). The mapping of that sheet presents no difficulty, the three divisions of the Norfolk drift, the Lower Glacial Brickearth, the Middle Glacial Sands, and the Chalky Boulder Clay occurring in regular succession (fig. 77). To the south of Norwich, exposures of the Lower Glacial Brickearth become intermittent. Further to the south, in Suffolk, beds of sandy clay and brickearth occur in places, which seem to be of Lower Glacial age. Wood held strongly to the opinion that the Lower Glacial clays formerly extended over the eastern part of Suffolk, and that, although much denuded at a later stage, masses of them may still exist, concealed under the Chalky Boulder Clay of that region.

The Contorted Drift of the Cromer coast, equally with the Norwich Brickearth, occasionally contains crystalline erratics of moderate size, rarely to be observed, however, *in situ*, but here and there, lying on the beach, or inland near farmhouses, or as *rejectamenta* in brick-pits. The opinion has been expressed that some of them may be of Scandinavian origin. As a rule, however, they are not of a sufficiently distinctive character to enable the petrologists to whom I have submitted my specimens to express a decided opinion as to their origin.† The boulders of diabase frequently met with may be British, possibly derived from the Whin Sill. Mr. Kendall informs me, on the authority of

* Mr. H. B. Woodward has expressed a similar view. *Proc. Geol. Assoc.*, vol. ix, p. 125, 1885.

† Pebbles of Scandinavian rocks are sometimes met with on the beach, but these do not necessarily prove that the Scandinavian ice-sheet reached East Anglia.

Professor Brögger, that there is no large area covered by such rocks in Scandinavia.*

In a deep railway cutting near Utrecht, on the contrary, which I visited with Dr. Lorié, I noticed, in sandy beds of a similarly contorted character to those of Norfolk, an enormous number of large granitic and other crystalline boulders clearly recognisable as Scandinavian.† These morainic deposits are believed by Dr. Lorié to represent a part of the south-western limit of the Baltic ice-stream.‡ They show a much closer, and a different kind of relation to it than do the drifts of the Cromer coast. Scandinavian erratics have, however, been noticed in the boulder clays of Yorkshire and Lincolnshire. On the other hand, the masses of chalk in the Contorted Drift, often in a marly condition, as if they had been subjected to the pressure of ice moving over them, seem to me to establish a close connection between the Norfolk deposits and some Chalk strata, then existing to the north-west, and possibly, as Mr. Reid suggests, at no great distance.§ The character of the Contorted Drift itself, becoming more marly as we trace it towards the north-west, points in the same direction.

I suggest, as a working hypothesis, that all these beds—the pebbly gravel, the Cromer Till, and the Contorted Drift, as well as the disturbance of the latter, and the introduction of the marl masses, may have been due to ice which travelled towards the lower ground of Eastern Norfolk to the east of the Wolds, being possibly pressed against the Wolds by the North Sea ice.

As the ice began to travel in a south-easterly direction, but before it had reached the Cromer coast, streams might have issued from the ice foot, bringing over the eastern portion of Norfolk and Suffolk quantities of flint pebbles, the Lower Glacial Clays, and the Contorted Drift representing its nearer approach.‖

The Hasboro' Till seems also to have come from the north-west; there is no trace of the existence of any bed of the same character far inland; moreover, the presence in it, as in the Contorted Drift, of fragments of marine shells, shows that the ice to which it was due approached Norfolk from the sea.

The Contorted Drift differs essentially from the Chalky Boulder Clay, not only in the character of its included erratics, but also, in what is of greater importance, in the material of which it consists. As has been long known, the larger boulders in the Lower Glacial are mainly those of igneous rocks, those of diabase being the most abundant. In the Upper Glacial, on the

* My friend, Mr. H. B. Muff, F.G.S., has recently examined microscopically some boulders from the Norwich Brickearth, and finds them to be of diabase, and not of dolerite, as formerly supposed.

† See also Lorié, *Contr. a la Géol. des Pays Bas.* part 2, *Arch. Teyler*, 1887.

‡ See map, pl. xxxiv, *Quart. Journ. Geol. Soc.*, vol. lii, p. 782, 1896.

§ *Mem. Geol. Survey*, Cromer, p. 113, 1882.

‖ The occasional presence of red flint (supposed by Mr. Reid to be of Danish origin, *Mem. Geol. Surv., Holderness*, p. 18, 1885) in the Pebbly gravels, as in the basement clay of Bridlington, shows, however, that some connection between the East of England and the Scandinavian ice had, by this time, been established.

contrary, igneous boulders are rare, but, as all observers have recognised, débris from Secondary strata, seldom in the form of large blocks, is exceedingly common. The Chalky Boulder Clay is always, as its name denotes, of a more or less stiff and clayey nature, and forms wet, heavy, wheat-growing land, as, for example, in middle and south Norfolk, and in Suffolk and Essex. Not only does it contain abundantly in these counties, fragments and boulders of Jurassic as well as of Cretaceous rocks, but its matrix is often of a dark blue colour, having evidently been derived from Secondary clays. On the other hand, the Contorted Drift, where it is not marly, assumes the character of a sandy brickearth, with associated beds of sand and gravel, and the district it covers is regarded locally as "good mixed soil," and never as "strong clay land." As the Chalk highlands are approached, however, the Upper and Lower Glacial deposits resemble each other more nearly; the matrix of the latter being very chalky in north-west Norfolk, and that of the former, where it rests on the Chalk, as near Hitchin, or in Lincolnshire, where it hugs the western and southern parts of the Wolds, decidedly so.* In spite of this exception, not in any way antagonistic to the views expressed in this paper, the marked difference in the character of the two deposits over the greater part of the district, as well as that of their included boulders, indicates that the ice streams to which they were severally due must have crossed in their journey to East Anglia a different series of rocks, and have followed different routes.

The latter point seems further indicated by the fact that, while shell fragments frequently occur in the Lower Glacial Clays of East Anglia, they are not found in the Chalky Boulder Clay of that region.

Although the Lower Glacial beds may sometimes represent the moraine of moving ice, as is probably the case towards the west, where they assume their marly condition, they have often, when they consist of brickearth, the appearance of an aqueous deposit originating in a closed basin from which tidal currents were excluded, in which fine mud could quietly settle. When the North Sea was blocked by the Scandinavian ice, such a closed basin might have existed to the south of the ice foot, a great glacier-lake in fact, in which the drainage of the continental rivers flowing northwards accumulated. In this way, I suggest, some of the Lower Glacial brickearths, which closely resemble the recent alluvium of the Rhine and the Meuse, may have originated. It would be interesting to ascertain the result

* As Mr. H. B. Woodward points out, it is not easy in west Norfolk to distinguish between the marly clay of Wells and Fakenham, and the Chalky Boulder Clay of the district to the south of the latter town. In a geological map recently published by him ("Victoria History of the County of Norfolk," 1901) following the lithological method of mapping the East Anglian drift beds adopted by the Survey, he uses the same colour for the two deposits, but he agrees with me in believing the former to be of Lower and the latter of Upper Glacial age.

of a more accurate comparison of the latter deposits with our own.*

The volume of water brought down by these rivers during the Glacial period must have been far greater than that of our own times. Not only would the melting of the ice covering the Alpine region produce violent floods during the summer, but generally the rainfall of Western Europe may have been greater. The existence of permanent ice, and of arctic conditions so far to the south, and over a region the winters of which are now abnormally mild, must have produced much meteorological disturbance, and increased precipitation. The "pluvial epoch," which has often been insisted on, and has been usually regarded as post-glacial, may have commenced in glacial times.

THE MIDDLE GLACIAL SANDS OF EAST ANGLIA.

This formation, which occupies, more or less continuously, a large area in the eastern part of the counties of Suffolk and Norfolk, attaining a maximum thickness of 60 or 70 feet,† indicates an important and clearly defined stage in the glacial history of the district.

In the south-eastern corner of Suffolk, from the Stour to the Alde, the area lying to the south-east of a line joining Ipswich, Woodbridge, and Aldeburgh (that of the Red Crag), it forms a succession of sandy heaths on the higher land intervening between the valleys by which that region is intersected, the underlying Crag being exposed only along the sides of the valleys.‡ In places, the Middle Glacial Sands have denuded the Crag, as at Wilford Bridge, near Woodbridge.

To the north and north-west of the Red Crag area, these sands pass under the great sheet of Chalky Boulder Clay which covers the higher part of Suffolk and south Norfolk; in that district the sand comes to the surface in the valleys only, where erosion has cut through the Boulder Clay to a sufficient depth. Along a narrow strip of country in east Suffolk, however, extending from Aldeburgh to Yarmouth, the Middle Glacial is more largely exposed, as the Boulder Clay only reaches the coast at a few points.

Beyond Norwich, the Lower Glacial brickearths are overlain by sands of a similar character, which form extensive heaths of very light land to the north of that city; that these sands occupy

* The microscopical and analytical study of the constituents of the glacial clays of East Anglia is likely to give results as interesting as that of the stones or the boulders they contain. It ought to be possible in this way, I think, to ascertain with absolute certainty the paths of the ice streams.

† It was proved to be 69 ft. thick at East Dereham (*Mem. Geol. Survey*, Dereham, p. 55) and it exceeds 50 ft. at Wilford Bridge.

‡ A reference is suggested to a sketch map of this district in *Quart. Journ. Geol. Soc.*, vol. lii, pl. xxxv, and to Mr. H. B. Woodward's map of Norfolk (see footnote on last page).

generally the same geological horizon, though possibly they may not be absolutely synchronous with those of Suffolk, is shewn by the fact that the former, when traced eastwards towards Yarmouth, pass under the Chalky Boulder Clay, while the latter, followed northwards in the same direction, pass over the Lower Glacial Brickearth.

Towards the south of the area covered by them, the Middle Glacial beds become, as before stated, gravelly, and occasionally, as near Lowestoft, they contain pebbles, possibly derived there at second hand from the Westleton beds. Their more general character is, however, that of rather coarse-grained sand, often current-bedded, with occasional seams of small subangular fragments of flint, or small, rounded pellets of chalk. In places, in the upper part of the sands, and where they are protected by an overlying covering of boulder clay, they are sometimes largely composed of chalk grains, which were found in one case to form more than 30 per cent. of the whole.* Such deposits may indicate the re-establishment of glacial conditions in East Anglia, and the near approach of the Chalky Boulder Clay ice. Where the Middle Glacial comes to the surface, and is unprotected by clay, chalk grains have been removed by the infiltration of acidulated water, and the sands have been stained a bright yellow colour by peroxide of iron.

In the year 1868, when mapping the district known as the Flegg Hundred (fig. 77), to the north-west of Yarmouth, I came accidentally on a rich fossiliferous seam in the Middle Glacial Sands at Billockby and Clippesby (villages about seven miles north-west of that town), which had been protected from decalcification by the Chalky Boulder Clay immediately overlying it.

Fossils were afterwards discovered at the same horizon at Lound, five miles to the south of Yarmouth, and at various places in the cliff section.† Wood, sifting with the most indefatigable industry some tons of the material, obtained from these sands a very interesting and important fauna of more than 100 species of Mollusca, the general facies of which was of a glacial‡ and very recent character, including forms like *Tellina balthica*, *T. crassa*, *T. obliqua*, *Scrobicularia piperata*, *Mactra ovalis*, *Corbula striata*, *Mya arenaria*, *M. truncata*, *Pholas crispata*, *Cyprina islandica*, *Cardium edule*, *Nucula cobboldiæ*, *Mytilus edulis*, *Pecten varius*, *P. opercularis*, *Anomia ephippium*, *Trochus cinerarius*, *Natica catena*, *N. alderi*, *Littorina litorea*, *Turritella terebra*,

* In the report of an analysis of some Middle Glacial Sand made for me many years ago by Mr. Fras. Sutton, F.C.S. (*Geol. Mag.*, vol. iii, p. 43), the percentage of carbonate of lime was stated by a printer's error to be 3‡. It should have been 31·2.

† John Gunn, the Rector of Irstead, had found marine shells in the Middle Glacial Sands of Caister, near Yarmouth, as far back as 1836. See also C. B. Rose, *Proc. Geol. Assoc.*, vol. i, p. 192, 1861.

‡ The Ostracoda of the Middle Glacial Sands, all of them of marine species, are generally of a northern character. Brady, Crosskey, and Robertson, *Pal. Soc.*, 1874, p. 103.

Trophon (Neptunea) antiquus, *Purpura lapillus*, *Buccinum undatum*, and *Nassa incrassata*. Among the northern forms found may be mentioned, *Panopæa norvegica*, *Tellina lata*, *Astarte borealis*, *A. compressa*, *A. sulcata*, *Leda oblongoides*, *L. lanceolata*, *Natica clausa*, *N. helicoides*, *Scalaria groenlandica*, *Bela turricula*, and *Trophon scalariformis*. Under ordinary conditions

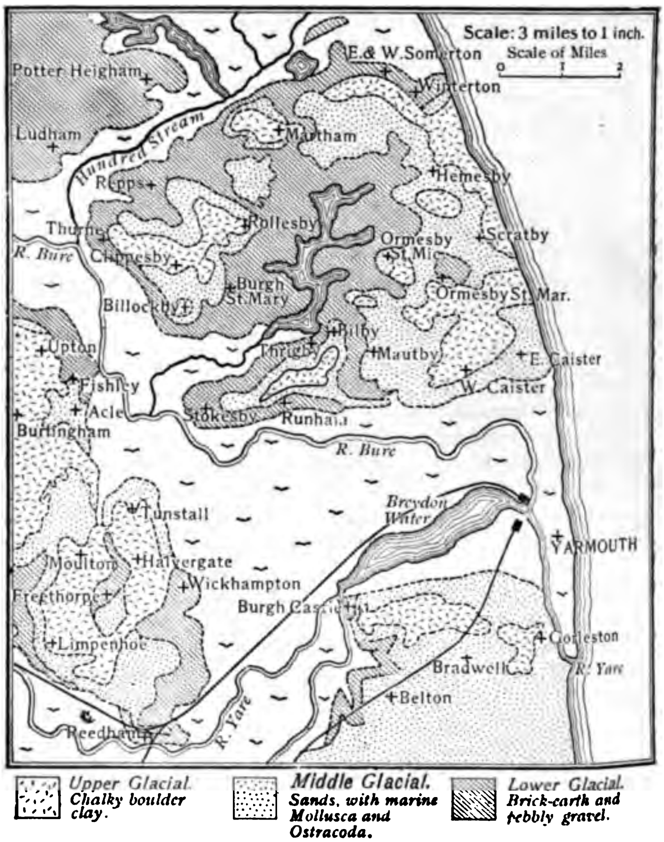

FIG. 77.—THE FLEGG HUNDRED.

these shells would have been regarded, without hesitation, as the contemporary fauna of the Glacial deposit in which they occur, but Wood found also with them a few specimens of southern and extinct species which had been common in the North Sea during earlier and middle Crag times, but, as far as we know, had died out in that region before the Glacial period. Among these were *Cytherea rudis*, *Woodia digitaria*, *Astarte burtinii*, *A. omalii*, *Erycinella ovalis*, *Cardita scalaris*, *C. corbis*, *Leda pygmæa*, *Dentalium dentalis*, *Calyptræa chinensis*, *Turritella incrassata*, and *Trophon muricatus*. To explain the anomaly of the presence of such shells in a glacial deposit, the hypothesis was suggested that they had been derived from some older Crag beds, but this view, for which no evidence has been offered, I am entirely unable to accept. There is no reason to suppose that while most of the specimens are proper to the deposit, others are derivative; they are all in the same mineral condition, and no distinction can be drawn between them.

Many are exceedingly fragile, as for example, young shells of *Anomia ephippium*, from ⅛ inch in diameter, which are very common, and almost as thin as tissue paper. Most are small, such as might have been brought into the area by tidal currents. Although some are fragmentary and broken, others are as perfect as the shells of the Coralline Crag, a deposit the fossils of which were accumulated, I believe, in a somewhat similar way.

It is not the more distinctive large and strong species of the Coralline or Red Crags, whose presence might have been expected on the derivative hypothesis, as, for instance, *Trophon* (*Neptunea*) *contrarius*, so abundant in every part of the latter, that we commonly find in these beds. On the contrary, in the Glacial deposit in Aberdeenshire, already alluded to, containing derivative Crag shells, no small or fragile species were met with, the specimens being all of a more or less solid character.* Moreover, if any older Crag deposits had then existed in the Yarmouth area,† they would have been covered by a considerable thickness of Lower and Middle Glacial deposits, since it was from the highest part of the latter that the shells were obtained. If further argument were needed in opposition to the derivative theory, it would be supplied, I think, by the inspection of the specimens themselves, preserved in the Castle-Museum at Norwich.

If the view here taken is correct, it follows that the connection between the North Sea and the English Channel which, I believe, existed during the deposition of the Lenham and Coralline Crags, but was interrupted at the commencement of the Red Crag period, was re-opened in Middle Glacial times.‡ That an alteration took place at this stage, both in the physical conditions of the area and the character of the sediment, is obvious. The accumulation of brickearth, composed of fine material, tranquilly deposited, or of glacial clays, suddenly gave place to that of rather coarse, stratified, and false-bedded marine sands, due to current action. A possible explanation suggests itself.

* The Aberdeenshire specimens were submitted to S. V. Wood, Senr. He was as strongly of opinion that they were derivative, as he was that the Middle Glacial fossils were not so.

† This does not seem probable, as the borings in north-east Suffolk have revealed no Crag beds older than those of the Norwich zone.

‡ A similar view has been expressed by Mr. C. Reid, *Mem. Geol. Survey*, Cromer, p. 93, 1882.

The result of the blocking of the North Sea by the Scandinavian ice must have been that the level of the extra-glacial lake so formed would have been gradually raised by the continued accumulation of the water brought into it by the Rhine and its affluents, then flowing, as before urged, in greater volume than at present. Eventually, however, these waters might have forced for themselves an outlet towards the south-west, permitting the tidal currents of the English Channel again to find their way into the German Ocean, bringing with them a few of the Mollusca of more southern seas.

How far the changes to which the Middle Glacial sands were due may represent or have been locally the cause of interglacial conditions in East Anglia, must be left an open question. No large erratics, implying the presence of floating ice in the North Sea at this stage, have, however, been met with in these beds. The absence of any evidence to show the existence of glacial conditions during the deposition of the Middle Glacial sands in the part of East Anglia covered by them is an interesting and important fact, which should not be lost sight of.

THE UPPER GLACIAL DEPOSITS OF EAST ANGLIA.

The Chalky Boulder Clay, and the Plateau (Cannon-shot) Gravels.

Passing from the loams and brickearths of the region immediately to the north of Norwich to the great sheet of Boulder Clay which, coming on suddenly to the south of that city, extends, in a more or less continuous sheet, to the brow of the Thames Valley, one cannot but notice the striking difference between the two.

The Chalky Boulder Clay, the most important of the glacial deposits of East Anglia, has of late years received less attention from geologists, other than the officers of H.M. Survey, than those of the Cromer coast, possibly because the latter are more accessible, and because few good sections are now available in the former. One such, of considerable extent, may be seen, however, in a railway cutting at Forncett Junction, near the spot where the branch to Wymondham leaves the main line from Ipswich to Norwich.

The Chalky Boulder Clay covers an enormous area, as shown in fig. 78 (copied from a map published by S.V. Wood, Junr., in 1880),* extending from the north of Lincolnshire into Middlesex, and from the Midland Counties to the East coast, more than 130 miles in each direction.

* "The Newer Pliocene Period in England."—*Quart. Journ. Geol. Soc.*, vol. xxxvi pl. xx.

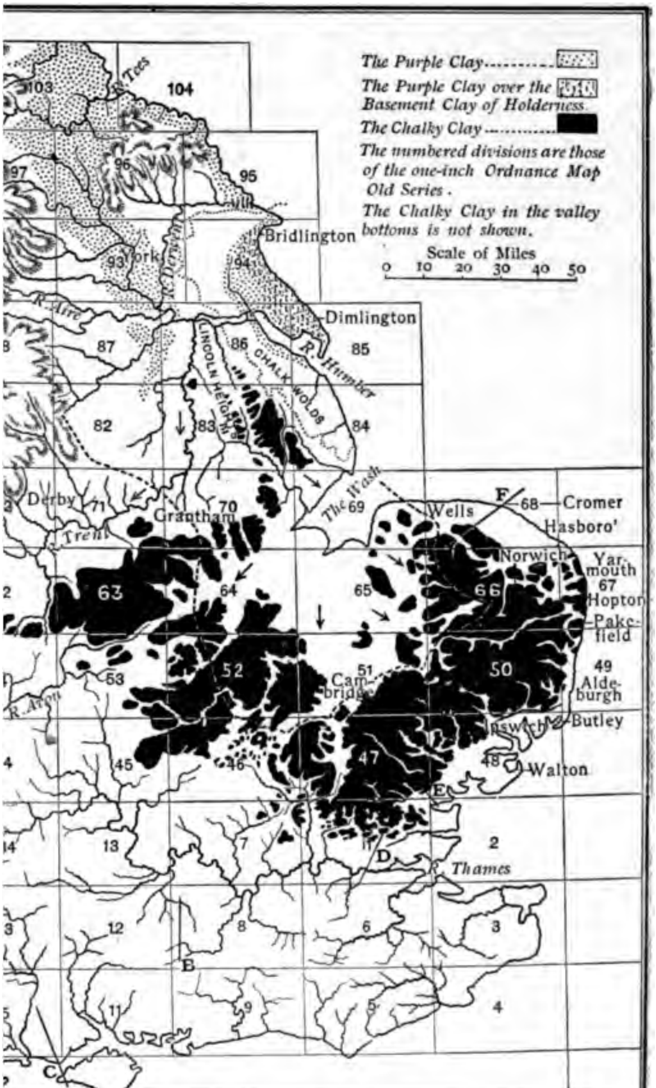

Fig. 78.—Map showing the Distribution of the Purple and Chalky Boulder Clays of the East of England

(The arrows show the suggested direction of the ice-flow.)

In East Anglia it is everywhere *sui generis*, and can be easily distinguished from other deposits; although its constituent materials vary greatly, according to the rocks over which the ice travelled, its matrix being in places composed of blue Jurassic clay, as at Forncett, and at others largely of chalk, it presents the same general character, always containing abundantly minute fragments of chalk, in the same way that a cake is full of currants. Whatever the material the Chalky Boulder Clay mill had to grind, the finished product was of a similar character. It is now generally believed to have been due to the action of land ice.

The material of which it consists has been derived almost entirely from secondary strata, Cretaceous and Jurassic, and especially from such rocks as are present in Lincolnshire and Cambridgeshire. Everywhere it includes fragments of hard chalk, and the white or grey flints of the former county; Red Chalk, Neocomian sandstone, Kimeridge Clay, Coral Rag, Oxford Clay, and Lias, with erratics from the more distant carboniferous rocks, and, occasionally, some of igneous origin, may also be constantly recognised in it in different parts of the district.

In Norfolk and Suffolk the Chalky Boulder Clay rests in places on glaciated marly Chalk, the ice having apparently ploughed out any beds newer than the Chalk which may have there existed. Over the eastern part of those counties, however, it is underlain by the Middle Glacial Sands, which generally show no signs of disturbance at the junction of the two deposits, a fact which it is not easy satisfactorily to explain. The most reasonable hypothesis seems to be that given by S. V. Wood, Junr.,* who pointed out, on Nordenskiöld's authority, that the edge of the ice of Greenland and Spitzbergen is of no great thickness, and that it presents a low and shelving face as it approaches the sea, being preceded by a sloping bank of mud. He suggested that such a mud bank may also have been caused by and have preceded the ice stream which crept over East Anglia at this period. As the latter moved down from the higher land, erosion of the soft Secondary rocks would take place, and the greater part of the eroded material would be pushed forward by the ice; when the ice sheet diminished in thickness, and the gradient along which it moved became less, not only would its eroding power become smaller, and eventually cease, but it would no longer be able to drive before it the whole of its moraine; some would be left behind to form a cushion, over which the thin edge of the advancing ice might move without disturbing the underlying strata.†

The view taken by Wood and myself was that the Chalky

* *Quart. Journ. Geol. Soc.* vol. xxxvi, p. 487, 1880.

† It has been suggested that boulder clay may sometimes have been due to material existing in the ice, and left behind when it melted. This view seems inapplicable to the Chalky Boulder Clay, however, as it does not account for its uniform, and apparently ground up character, nor does it explain how it was that the ice could move over the Middle Glacial sands without disturbing them.

Boulder Clay was in some such way as this distributed over East Anglia by an ice stream, for which I propose the name of "The Great Eastern Glacier," which descended from the region covered by Jurassic rocks intervening between the Lincoln Heights and the Lincolnshire Wolds, then possibly of greater elevation than now. Getting clear of the hills, such a glacier might naturally have spread itself out like a fan, in the way suggested by the distribution of the Boulder Clay shown in fig. 78, moving towards Yarmouth in one direction, and Leicester in another. Still lying in considerable thickness over sheets 69, 64, 65, and 51, it might have ploughed out from that area the Jurassic strata of which the enormous mass of the Boulder Clay covering East Anglia is largely composed, leaving when it eventually melted the great depression now occupied by the Fens. Continuing to travel outwards in all directions in an attenuated condition, the ice would cease to erode, but instead would override part of its moraine, another part being still carried forward and spread out in a sheet, which became gradually thinner as it was moved further from its source.

Other theories as to the origin of the Chalky Boulder Clay have, however, been advanced, and to these it is necessary briefly to refer. The one which has received the most support is that adopted by Prof. James Geikie, who, in a well-known work, gives a map, showing the Scandinavian ice at the time of its maximum extension, crossing East Anglia from the North Sea, in a N.E.—S.W. direction.* This conclusion seems to me untenable, however, in the face of the fact, shown above, that the Chalky Boulder Clay does not exist in the north-eastern part of Norfolk, between the Cromer and Hasboro' coast and Norwich, though it comes on suddenly immediately to the south of the latter place, along a line running at right angles to that of its supposed movement (see fig. 78). Even if we accept the view that the disturbance of the Contorted Drift was to some extent due to the North Sea ice during the Chalky Boulder Clay period, we must remember that such contortions become less numerous as we trace the Lower Glacial beds southward from the Cromer coast, and are unknown in the neighbourhood of Norwich.† The Rev. E. Hill, examining microscopically the matrix of the Suffolk Boulder Clay, has come to the conclusion that the Chalky Boulder Clay ice came, not from the North Sea, but from the west or north-west.‡ There is, however, no high land in the former direction, and it is difficult to imagine that any snowfield could ever have existed in the Midlands of sufficient extent and elevation to have initiated the great ice-sheet

* The Great Ice Age, 3rd Edit., pl. IX. p. 437, 1894.

† The disturbances near Norwich are due, as will be shown later on, to ice moving down the valleys, and not to ice coming across the county from the N.E. Disturbances, of a trifling character, may be observed in places, however, in the Norwich brickearth.

‡ *Quart. Journ. Geol. Soc.*, vol. lviii, p. 179, 1902.

which overspread the Eastern Counties. Mr. Hill, equally with myself, however, opposes the view that the Chalky Boulder Clay came from the eastward, expressing the opinion, taking matrix and inclusions together, that 99 per cent. of the material of which it is composed is of westerly and Secondary origin. It has also been suggesed that the North Sea ice might have entered East Anglia through the gap now forming the Wash, and having done so, that it fanned out in all directions—to Yarmouth, to Middlesex, to the Midland Counties, and to North Lincolnshire. In such case, however, it must have lain in great thickness off the Norfolk coast, and it is difficult to understand why it did not also override north-eastern Norfolk, and have taken the direct course towards Yarmouth, across sheet 68 (fig. 78), instead of the circuitous route by sheet 66. Moreover, on this view, it is not easy to account for the great abundance of hard chalk, and the grey flints, or the Neocomian erratics in the Chalky Boulder Clay.* It is true that hard chalk and grey flints occur in the *Terebratulina gracilis* zone of the Middle Chalk in West Norfolk, but those beds come to the surface there along a narrow belt only, insufficient, I think, to account satisfactorily for the abundant presence of such materials in the East Anglian Drift. It is rather to Lincolnshire, where these strata exist over an extensive area, to which we must look for their origin. Mr. Lamplugh states that the Neocomian boulders so common in West Norfolk are not identical with any known exposure of such rocks in Lincolnshire, but neither, it might be added, do they resemble anything existing on the Norfolk borders of the Wash. Mr. Jukes-Brown informs me, however, that there are boulder-like masses of calcareous sandstone in the Spilsby beds which are very similar to these erratics, and it is from an extension of such beds now destroyed, he suggests, they may have been derived. He informs me, moreover, that they are not met with on the opposite or western border of the Lincolnshire Fens, between Stamford and Heckington; had the ice come from the Wash, these boulders having been derived from some Neocomian strata formerly existing in that region, they ought to be even more abundant in the area alluded to than they are in Norfolk.

Messrs. Jukes-Brown and Strahan in their Lincoln Memoir (sheet 83) express a decided opinion that in that district the ice moved from N. to S., and not from S. to N. The latter says that the Boulder Clay, which has clearly been derived from the Wolds, and is intensely chalky where it rests against them, becomes less so towards the south and the west, and that this type of clay

* Mr. Muff, has recently found, for example, in the boulder clay of a railway cutting near Haverhill, in west Suffolk, five large Neocomian erratics and Mr. Whitaker identified the sandstone boulders of south-west Norfolk, including the well-known one at Merton, near Watton, as of Neocomian origin. *Mem. Geol. Surv.*, Attleborough, p. 10, 1884. Similar erratics are also abundant at Forncett. Mr. Muff reports many boulders of gannister, Mill-Stone Grit, and Carboniferous Limestone, from the boulder Clay of the neighbourhood of Cambridge.

extends further towards the south than towards the west, trailing round the south end of the chalk range. He infers from this, and from the distribution of the other Glacial deposits of Lincolnshire, that the direction of transport was there from north to south.*

Mr. Jukes-Brown mentions also the case of an enormous boulder of chalk at Martin, near Timberland, about 10 miles S.E. of Lincoln, which he considers has been brought from the northern part of the county, as well as of some large blocks of Neocomian sandstone at Langton, near Horncastle, which seem to have been moved from N. to S., and of others, near Middle Rasen, of Oolitic limestone from the W.

While, however, such evidence tends to show that in the main the Lincolnshire ice travelled from N. to S. there must also have been, at some stage in the Glacial period, a movement outwards from the Wolds in a south-westerly direction.† This is not only shown by the fact that the Lincolnshire Boulder Clay is found to contain a diminishing quantity of chalk as it is traced from E. to W. across the plain intervening between the Wolds and the Oolitic escarpment; but as Mr. Skertchley, dealing with the district to the north of the Lincolnshire Fens, points out, while the composition of the Boulder Clay in that area resembles closely the rocks upon which it rests, the very chalky clay extends over that formed partly from the Neocomian rocks, the latter invades the Kimeridgian area, and this again that of the Oxford Clay,‡ the inference being that the ice moved in that district from N.E. to S.W. He suggests, it is true, that the reason for a movement in that direction was that the North Sea was then blocked with ice, but he does not show any sign of thinking that the latter invaded East Anglia from the Wash. From the particulars given by Mr. H. B. Woodward of the sections disclosed during the construction of the railway between Bourn and Saxby, near Melton Mowbray, it does not appear that the state of things alluded to by Mr. Skertchley obtains to any great extent to the west of the Fens, that is to say to the S. of the region described by the latter, Oxfordian fossils having been found to preponderate in the Boulder Clay of the eastern portion of the district so exposed, Great Oolite fossils in the central, and Liassic fossils in the western part.§ These three areas seem more or less closely to correspond with the outcrops of the secondary rocks referred to, the inference being, as it seems to me, that there the ice travelled approximately from N. to S., and not from E. to W.

The presence of chalk in the Boulder Clay of the country lying to the west of the Oolitic escarpment, and in the valley of the Trent, along the northern part of which Mr. R. M. Deeley

* *Mem. Geol. Survey*, Lincoln, pp. 130-5, 1888.

† Mr. Goodchild alludes to the existence of cross-currents, perhaps of a similar character, in the ice of the Eden Valley. *Quart. Journ. Geol. Soc.*, vol. xxxi, p. 89, 1875.

‡ *The Fenland*, p. 519, 1878.

§ *Geol. Mag.*, Dec. iv, vol. iv, p. 486, 1897.

In a paper contributed to the Geological Society in 1866, I called attention to the fact, that Chalky Boulder Clay assumes the character of a valley deposit in the neighbourhood of Norwich.* Soon after, excavations for the Norwich Sewer Works revealed the existence of a mass of similar clay extending to an unknown depth below the sea level at the bottom of the Yare valley, just above its junction with that of the Wensum.† Many similar cases are now known to me, but there is one of special interest at Thorpe, near Norwich, to which I hope to call the attention of the members of the Association during their proposed visit to Norfolk, showing that the Yare valley was during the latter part of the Chalky Boulder Clay period occupied by a glacier of considerable size.

The valley at this spot has been excavated interglacially out of the Crag, and the older Glacial deposits (fig. 79).

Near the Lunatic Asylum, in the well-known Thorpe section (2), the Norwich Crag is shown to rest on undisturbed Chalk, the Crag being overlain higher up by Lower and Middle Glacial beds. The Crag may be also seen at Whitlingham, on the opposite side of the valley, at this point half a mile wide, resting on the Chalk, which, at one pit, is equally undisturbed. Within the valley, however, and but little above the level of the river, there is a pit of Chalky Boulder Clay resting on Chalk in a marly and glaciated condition (4). Nearly opposite the Asylum, on the Whitlingham or south side of the river, and not far from the last-named section, is another quarry (5) where, forty years ago, the photograph from which fig. 80 is copied, was taken by the late Mr. Howes.‡ This section showed that the Chalk and the sands overlying it had been violently disturbed, the lines of flint having been forced up into a sharp anticlinal disturbance. Moreover, on the north side of the river, and not far from the Thorpe Crag pit (2), the Lower Glacial Brickearth and the Middle Glacial sands have also been disturbed (1), while a recent road excavation near the Asylum (3), shows the Boulder Clay as a valley deposit dipping towards the Yare, and ploughing out the Crag beds down to the Chalk. These facts, all closely connected, and doubtless due to the same cause, show, I think, that at this stage of the glacial history, ice, at least a hundred feet in thickness, impinging on the Chalk, and producing the contortion portrayed in fig. 80, continued to creep down the Yare valley. I believe this example to be a typical and not an anomalous one. All who know the district intimately are familiar with the fact that the Chalky Boulder Clay seems constantly to plunge into the valleys.§

* A Third Boulder Clay in Norfolk. *Quart. Journ. Geol. Soc.*, vol. xxii, p. 87, 1866.

† Intraglacial Erosion near Norwich. *Quart. Journ. Geol. Soc.*, vol. xxv, p. 445, 1869.

‡ Reprinted from the "Geology of England and Wales," by the kind permission of Mr. H. B. Woodward.

§ At Cringleford, for example, excavations in my own grounds have shown that Boulder Clay not only underlies the Pleistocene gravels of the River Yare, but that it occurs in patches at different levels on the sloping sides of the valley.

Of later age than the Chalky Boulder Clay are some Plateau Gravels which occur at several places in the neighbourhood of Norwich, as at Mousehold Heath to the north of the city, where they rest on the Middle Glacial Sands, and at Strumpshaw, and Poringland, to the south and east, where they overlie the Chalky Boulder Clay. They are largely developed near Wymondham, and thence extend into central Norfolk.

Composed principally of flints, often of large size, they have evidently been accumulated under the influence of violent floods,

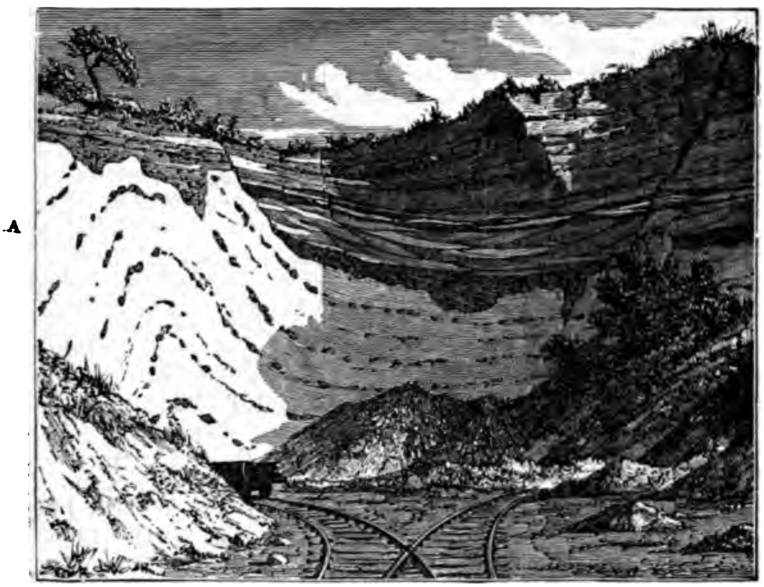

FIG. 80.—SECTION SHOWING THE DISTURBANCE OF THE CHALK, AND OVERLYING BEDS BY ICE MOVING DOWN THE VALLEY OF THE YARE.

A—Chalk. B—Norwich Crag. C—Pebbly Gravel.

and represent the waning of glacial conditions in East Anglia, when the destructive and constructive agency of water was replacing that of ice. Similar gravels exist in north Norfolk, as at Holt, and to the south of Cromer. The latter, possibly belonging more or less to the same period, may have been connected with the North Sea ice, rather than with that to which the Chalky Boulder Clay was due. One interesting fact should be pointed out. The plateau gravels occur not infrequently along the sides of the valleys, great and small, sometimes at the very edge of the higher land by which they are bounded, as at several

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Suffolk, where they have been regarded as of "h
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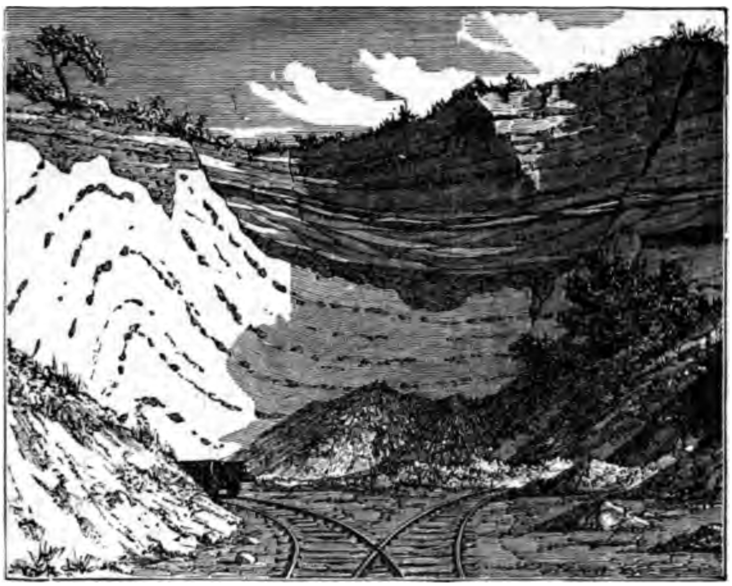

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THE POST-GLACIAL AND RECENT DEPOSITS.

It will not be possible to deal here with the still later geological history of East Anglia, except in the most cursory manner. The subject of the surface denudation by which the district has acquired its present form is an interesting one, but it cannot now be discussed. It seems to me, however, to have been due to causes operating during and immediately succeeding the glacial epoch, of an entirely different character to those now obtaining. The general contour of the land, everywhere undulating or furrowed, except on the plateaux of hard, impermeable Boulder Clay, or on the heaths of absorbent sand, could not have been produced under present conditions however prolonged.

The valley gravels, as for example those exposed in the yard of the Great Eastern Railway station at Norwich (Thorpe), attain a height far beyond that of any floods which now occur. They could only have been deposited at a time when the land stood at a relatively higher level than at present, since the bottom of the valley cut out of the Chalk, within which they rest, is considerably lower than Ordnance Datum. At Norwich, they have been traced to a depth of about

* Mr. F. T. Bennett points out that the Cannon-shot gravel never crosses the valleys. *Mem. Geol. Survey*, East Dereham p. 1888.

20 ft. below the surface of the alluvium, but the valley bottom slopes rapidly down stream. At Somerleyton, on the railway between Norwich and Lowestoft, for example, the surface of the valley gravels was only reached at a depth of 70 ft. below sea level.

While these gravels thus represent a period when East Anglia stood at a higher level than that of the present, being probably joined to the Continent,* the deposition of the alluvial beds which rest on them was accompanied by a subsequent subsidence, during which the North Sea, reinvading its former basin, crept up the valleys, converting their lower reaches into estuaries. Estuarine conditions continue to this day in the southern part of East Anglia, as in those of the Stour and the Orwell. On the other hand, the valleys of the Bure, the Yare, and the Waveney, have been filled with silt or peat. The first-named are, in fact, in a condition of arrested development, the explanation of which may remind us of an interesting episode in the later geological history of the district.

The constant encroachment of the sea upon those parts of the East Anglian coast that are exposed to the tidal scour is a fact only too well known to the unfortunate owners of the land, the waste being as a rule greatest where the cliffs are high. So long as the latter are buttressed by talus, or by the accumulation of beach, they are safe, but when these are eaten away by the waves, and the cliff acquires a face more or less vertical, it falls by its own weight, its disintegration being hastened by the action of land-springs.† The fallen material protects it for a time, but eventually history repeats itself, and a further strip of land falls a prey to the hungry sea.

A considerable portion of the material derived from this waste of the land remains upon or near the shore, accumulating principally at comparatively sheltered spots. From another portion, however, have been formed those long narrow sand-banks which fringe certain parts of the coast, lying parallel to it, at no great distance from the land.

As is well known, the beaches of the eastern coasts of Norfolk and Suffolk have a tendency to travel from north to south, the currents running in that direction, those of the flowing tide, being the stronger. Efforts are frequently made to arrest this coastal movement, and so to cause accumulation at certain points, by the construction of groynes, but the protection of one spot is gained at the expense of other localities. Lowestoft affords a striking instance of this. The two long piers which enclose the harbour

* The considerable depth below O. D. to which the Chalky Boulder Clay extends in the Yare Valley seems also to indicate that Norfolk stood during its deposition at a somewhat higher level than now.

† The District Council of north-east Norfolk is at present perpetrating the almost incredible folly of removing quantities of shingle from the beach at Bacton for road mending.

at that place form a gigantic groyne. Large quantities of sand are constantly accumulating therefore to the north of the north pier, a sandy plain now extending from the pier head to the foot of the cliffs (the sea margin of a former period) upon which the old town of Lowestoft stands. On the contrary, little or no sediment can reach the shore to the south of the south pier, and the local authorities, so far as they are there endeavouring to protect the cliffs by groynes, seem to be engaged in an unequal and hopeless struggle.

The amount of material available for the formation of beach is strictly limited, depending on the waste going on towards the north. Where the cliffs are composed of sand, the beaches lying to the south are more or less sandy; where of gravel, they are stony. An example of the latter state of things is presented by the great shingle bank (derived from the pebble beds of a former extension of Dunwich cliff, now destroyed) which extends southward (fig. 66) from Aldeburgh, in Suffolk. The river Alde, immediately to the south of that town, approaches the sea at right angles, until within about 100 yards of it. It then turns abruptly to the south, and runs parallel to the shore, and near to it, finally reaching the sea at Hollesley, nine miles to the south-west. It is the gradual travel of the beach southward, and the accumulation of the great shingle bank of Orford Ness, between the river and the sea, that has altered the course of the Alde. Similarly the destruction of the cliffs of north Norfolk in former times has given rise to the sand-bank upon which Yarmouth has been built. Until this bank had finally established itself across the mouth of the Yare estuary, the tidal currents kept possession of its V-shaped valleys, heaping themselves up inland at high water, where the latter became narrower, to a level higher than that of the sea outside. Were it not for the existence of this sand-bank, and the fact that the influx of the flowing tide is confined to the narrow channel of the river between Gorleston and Yarmouth, similar conditions would obtain at present.

The estuarine condition of the Norfolk valleys seems to have continued until a comparatively recent period, as suggested by Samuel Woodward in a map of Roman Norfolk published in 1833.* Such a view is supported by the positions chosen by the Romans for their camps, at Burgh, Caister, and elsewhere. There is an old map in Yarmouth (the Hutch map) which shows a similar state of things as existing even in Norman times. In the district known as the Flegg Hundred, a triangular area in East Norfolk, bounded by the River Bure and the Hundred stream, (fig. 77), most of the names of the villages end in *by*, a proof of their Danish origin, while the majority of those on the opposite

* Archæologia, vol. xxiii, p. 358, 1833.

bank of the Bure have Saxon terminations.* It would seem therefore from this that in those troublous times the Flegg Hundred may have formed a region marked off by some natural boundary, protecting its inhabitants from sudden attack. Moreover, the Saxon Chronicle states that in A.D. 1004, Sweyn, with thirty ships, plundered and burned Norwich, marching afterwards from thence to Thetford. The inference has been drawn that the failure of a Saxon attack on the ships, in the absence of many of their defenders, may have been due to the estuarine condition of the Wensum valley at Norwich at that period.

There is no evidence to show when the Yarmouth sand-bank began to accumulate. Originating first as a submarine shoal, it grew until, at some time previous to the Norman Conquest, it had become an island, frequented by fishermen. We learn from a survey made by Edward the Confessor, about A.D. 1050, reported in Domesday Book, that Yarmouth had then seventy burgesses. The sand-bank may at this time have obstructed, though it did not wholly prevent, the daily flow of the tidal water into the estuary.

This is further shown by the existence of *salinæ*, pans for evaporating salt water, which are recorded as having existed at that period at Halvergate and Cantley, in the Yare valley, and in the Bure, at Runham, South Walsham, and other places some miles inland.

The protracted struggle between the growth of the Yarmouth sand-bank and the scour of the tidal currents marks a stage in the history of the Broadland district. Gradually but irresistibly creeping southwards, the bank drove the mouth of the Yare before it. At one time the river reached as far as Corton, a few miles north of Lowestoft, but in the sixteenth century an artificial opening to the sea was made for it at Gorleston, two or three miles to the south of Yarmouth; its further progress towards the south is now barred by the piers at Gorleston. Accumulation is taking place to the north of these piers, as at Lowestoft, and the cliffs to the south of them are wasting. All trace of the former channel of the Yare, for example, to the south of Gorleston, and between that place and Corton, has been destroyed by the encroachment of the sea.

The conditions of the valleys of the Stour and Orwell; of the Alde; and of those of the Bure and the Yare, may thus represent successive stages in the process by which the Broads have acquired their present features. The first named are still open to the sea because a smaller amount of material derived from the waste of the coast immediately to the north is there available. Similar causes are at work, however; a sandy spit extends southward from Felixstowe towards the mouth of the estuary of the

* Thurne, Repps, and Bastwick, are also Danish, and possibly Runham and Martham, the latter being, in Mr. Walter Rye's opinion, corruptions of Runholm, and Martholm.

Stour, and many submerged sand-banks exist in the offing The access of the tidal currents to these valleys is, however, for the present unobstructed.

For a long time the river Bure kept for itself an opening to the sea to the north of Yarmouth, but this was finally silted up in the fourteenth century. With the exclusion of the sea from the estuary by the blocking of its northern mouth, and of any similar opening which may have existed between Horsey and Winterton, along the Hundred Stream depression (fig. 77), the final stage in the evolution of the Broads commenced. Towards the sea, sediment, consisting partly of mud brought down by the rivers, which are turbid when in flood, and partly of tidal silt, was deposited in sheltered places as banks or shoals. Such deposition is still going on, as, for example, in Breydon Water, over the mud flats of which, as Mr. A. Patterson informs me, a small boat can hardly pass now, where thirty-five years ago a wherry could sail.

Further inland, beyond the point to which the tidal waters could penetrate, aquatic vegetation flourished in the water-logged soil, and along the banks or the shallower parts of the streams.

The first effect of the exclusion of the swiftly flowing tidal currents from the valleys of the Norfolk Broadland was to transform all the land below a certain level into a sheet, or possibly into several sheets of inland water, which gradually became smaller, and were finally reduced to a series of lakelets, by the deposition of mud, and the accumulation of decaying vegetation.

At a later stage, and by a similar process, impassable swamps became meadows, and cattle now graze in the former haunts of the crane and the bittern.*

From the valleys of the Waveney and the Yare, fresh water lakes have nearly disappeared.† Marshes protected from inundation by river banks, during the summer at least, extend from Norwich and Bungay, to Yarmouth and Lowestoft. Along the Bure, however, Broads still exist, occupying possibly the deeper parts of the old valley, the holes which have not yet been filled up. The agencies by the operation of which they came into existence are still at work, and will eventually bring them to an end, the more quickly perhaps because the rivers, the current of which tends to keep their own channels open, do not run through the Broads, but past them.‡

A portion of the Broadland, that traversed by the Hundred stream, once open to the sea, is now protected from its incursion by hills of blown sand, and by the sandy beach accumulating at their base. The sand dunes at this spot are gradually moving

* Breydon is the shrunken representation of the large sheet of water which must at one time have covered the low ground shown in the map (fig. 77), extending from Yarmouth, to beyond Reedham in one direction, and to the north of Acle in another.

† The Broads of Rockland and Surlingham in the latter are gradually disappearing.

‡ A comparison of the recent maps of the Ordnance Survey with those issued half a century ago will show that the Broads, taken as a whole, have been considerably reduced in extent during recent years.

inland, the sea following. When Sir Charles Lyell visited Norfolk in 1839, he found the ruined church tower of Eccles (a small village on the coast, to the south-east of Hasboro') half buried in the sand hills.* Twelve years afterwards, the latter having shifted, it stood clear of them to seaward, and it has since been entirely destroyed by the waves. Compared with the enormous dunes of some parts of the Dutch coast (two miles in width, for example, in the island of Texel), our own sand-hills afford a less secure protection to this part of the Broadland than could be desired. Much of the land is there below the level of high water, and were a breach in the cliffs once made the sea would take possession of the lower reaches of the Bure valley, and again convert the old Danish settlement of the Flegg Hundred into an island. It is probable that the safety of the district depends as much on the stability of the beach at this point as on that of the sand-cliffs, but step by step the sea is gaining on the land, and it is to be feared that nothing can permanently prevent its continued encroachment.

The time allowed for writing the second part of this paper was very short, the issue of a few copies in advance of its publication being required for the use of the Members of the Association taking part in the proposed excursion to East Anglia. Some slight alterations and additions have since been made in it, but it has still been impossible to read up properly the voluminous literature of the subjects with which it deals. My apologies may therefore be due to some whose published opinions, whether in agreement with my own or not, deserve a fuller notice or recognition than I have been able to give to them.†

REFERENCES.

One-inch Geological Survey Maps, sheets 48, 49, 50, 66, 67, 68.
Memoirs of the Geological Survey.
1882. C. REID.—"Cromer."
1881. H. B. WOODWARD.—"Norwich."
1884. H. B WOODWARD.—"Fakenham."
1890. J. H. BLAKE.—"Yarmouth."
1888. J. H. BLAKE.—"East Dereham."
1884. F. J. BENNETT.—"Attleborough."
1884. F. J. BENNETT.—"Diss."
1887. W. WHITAKER and W. H. DALTON.—"Halesworth."
1887. W. WHITAKER.—"Southwold."
1886. W. H. DALTON and W. WHITAKER.—"Aldborough."
1885. W. WHITAKER, W. H. DALTON, and F. J. BENNETT.—"Ipswich."
1877. W. WHITAKER.—"Walton Naze."
1890. C. REID.—"Pliocene Deposits of Britain."
1891. E. T. NEWTON.—"Vertebrata of the Pliocene Deposits."

* *Principles of Geology*, 10th Edit., vol. I, p. 513. Mr. Walter Rye informs me that a patent for the erection of this church on a new site was granted in 1338, the one existing at Eccles at an earlier period having been destroyed by the sea.

† My thanks are due to the Council of the Geological Society of London for permission to reproduce some of the diagrams accompanying this paper.

Lists of numerous papers dealing with the Geology of Norfolk and Suffolk may be found in the various Survey Memoirs.

Those by the present writer which have appeared since the date of their publication, and are specially referred to in this memoir, are

1896. "The Pliocene deposits of Holland." *Quart. Journ. Geol. Soc.*, vol. lii, p. 748.

1898. "The Pliocene deposits of the East of England."
Part I. "The Lenham beds and the Coralline Crag." *Quart. Journ. Geol. Soc.*, vol. liv, p. 308.

1900. Part II. "The Crag of Essex" (Waltonian). *Quart. Journ. Geol. Soc.*, vol. lvi, p. 705.

1901. "The Influence of the Winds upon Climate." *Quart. Journ. Geol. Soc.*, vol. lvii, p. 405.

Mr. H. B. Woodward has, moreover, recently published an interesting paper on the Geology of Norfolk, with a geological map of the county on the scale of one inch to four miles, showing the Glacial as well as the older deposits, to which reference should be made. (*Victoria History of the County. Westminster*, 1901.)

POSTSCRIPT.

Since the above has been in type, I have received from my friend M. Rutot, the well known Belgian geologist, copies of some important papers communicated by him to the *Société Belge de Géologie* in 1899, now appearing (in an amended form) for the first time.* I hope to deal more fully hereafter with the subject of the correlation of the Pleistocene deposits of Belgium and those of our own district, but there is one point dealt with in these papers which bears on a question raised by me on p. 461, viz, the probable conditions of East Anglia during the Lower and Middle Glacial periods, to which it may be interesting very briefly to refer. M. Rutot correlates the *Hesbayen* stage (one of the divisions of the Belgian Pleistocene) with the later part of the second glacial epoch of Prof. Jas. Geikie, but I think it may possibly be also represented by the Lower Glacial beds of East Anglia. M. Rutot points out that the *limon hesbayen* of Belgium, a stratified deposit which, in his opinion, is of freshwater origin, and was due to what he calls the "formidable Hesbayen flood, the most astonishing phenomenon of quaternary time," originated in a basin in which none but the feeblest currents existed (*une crue d'eau douce, mais de vitesse presque nulle*). At first occupying the lower part of the valleys, the water, the drainage of the Rhine and its affluents, rose constantly until it reached the higher terraces, and finally the plateaux, which it covered with a continuous sheet of mud, extending over

* *Le Creusement de la Vallée de la Lys, Bull Soc. Belge de Géol.*, t. xiii, p. 96, 1899 (issued October, 1902). *Comparaison du Quaternaire de Belgique au Glaciare de l'Europe centrale.* Op. cit. p. 307.

a great part of Belgium to the flanks of the Ardennes, as well as a considerable area in north-eastern France; according to M. Rutot, the Hesbayen Lake may have extended over the south of England, and possibly, I think, into East Anglia also. Towards the north, however, the *limon hesbayen* ceases suddenly along a line running N.W.—S.E., roughly parallel to what Belgian geologists consider to have been the southern extension of the Scandinavian ice, at a distance from it of a few kilometres only.* Finally, M. Rutot says, the flood ceased and the re-excavation of the valleys commenced. If these views of M. Rutot are to be accepted they seem to me to support that taken by me, that the Anglo-Belgian basin, during the deposition of the Lower Glacial beds, may have been still closed to the south by the barrier which came into existence early in the Red Crag period, separating it from southern seas, and to the north by a wall of ice; that in this tideless basin the drainage of the Rhine accumulated until it reached a level sufficiently high to enable it to force for itself an exit towards the south-west.† When this took place the pressure of such an enormous body of water as that evidenced by the Hesbayen deposits, at a level considerably higher than that of the ocean, might have quickly cut a wide and deep opening into the English Channel. Denudation on a large scale would ensue, not only in Belgium, but possibly in East Anglia also. The width of this strait would have been enlarged, moreover, by the tidal currents which must have unceasingly poured through it when the water of the Hesbayen Lake having escaped, and an equilibrium of level having been established, the deeper part of the Anglo-Belgian basin once more assumed the character of an inland sea.

Such an hypothesis seems reasonably to explain how the drainage of this extra-glacial lake might have been effected, and also how the marine and non-glacial conditions obtaining during the deposition of the Middle Glacial sand, with its fauna of boreal Mollusca, and of Ostracoda, could have been suddenly introduced into the East Anglian area.

* The deposits of the succeeding stage of the Pleistocene epoch (*Brabantien*) are believed by MM. Rutot and Vanden Broeck to be of Æolian origin.

† The view that the loess was due to the blocking up of the great rivers flowing north by the North Sea ice was originally suggested by Sir A. Geikie. "Great Ice Age," 2nd edition, p. 550, 1877.

EXCURSION TO SUFFOLK AND NORFOLK.

LONG EXCURSION, JULY 26TH TO AUGUST 5TH, 1902.

Directors: F. W. HARMER, F.G.S., AND W. WHITAKER, F.R.S.

Excursion Secretary: E. P. RIDLEY, F.G.S.

Report by H. W. MONCKTON, F.L.S., F.G.S. AND E. W. SKEATS, D.Sc., F.G.S.

(BY H. W. MONCKTON.)

THE party assembled at the Crown and Anchor Hotel, Ipswich, on Saturday, July 26th, and on the succeeding day many of the members visited the Ipswich Museum, where they were received by the Curator, Mr. F. Woolnough. The building is a comparatively new one and well adapted to its purpose. The collection of Suffolk fossils is particularly good, and Mr. Woolnough was most kind in drawing attention to the more important specimens, and in finding fossils which the members wished to examine.

Later in the afternoon the members attended a garden party, given at Burwood, by Mrs. Ridley.

MONDAY, JULY 28TH.

The party travelled by rail to Walton-Naze and examined the cliff-section, of which an illustration is given on p. 434.

The gravel, at the top of the cliff, 8 feet thick, is a stratified bed, and it practically caps the plateau, upon which a tower, a well-known landmark, stands. It consists largely of flint pebbles, but there is also a fair amount of subangular flint and a good many pebbles of quartz, and some pebbles of various other kinds. Fragments, almost certainly of Lower Greensand origin, occur. I found two in the course of a few minutes, and their presence suggests a stream or current flowing from the south-west. Prestwich classed this gravel with the Westleton shingle (*Quart. Journ. Geol. Soc.*, vol. xlvi, p. 128, 1890), and it no doubt much resembles the shingle of Westleton Common. It rests on clay certainly as new as Red Crag times, possibly Chillesford Clay, perhaps, as Mr. Reid thinks, even newer. (See Prestwich *op. cit.* at foot note, p. 128.) And probably, therefore, this gravel is more recent than the pebble-gravel of the Chiltern Hills, which Prestwich also classed as Westleton, but which I fancy belongs to an elevation of or before Coralline Crag date.

Mr. Harmer classes this gravel with that of Clacton, as also does Prestwich, but Mr. Whitaker expressed doubts as to this correlation.

The bed of clay below the gravel is, as I have already hinted, the subject of some difference of opinion. Mr. Whitaker originally suggested that it might be of Chillesford age,* and with this Prestwich agrees, whilst Mr. Reid thinks it is newer. Mr. Harmer classes both it and the gravel above it with the Red Crag.† The ferruginous sand with shells below the clay of doubtful age is bedded at a rather high angle. It is admitted by all to be Red Crag.

The junction of the Crag with the London Clay beneath it was seen in the cliff, but we had not time to examine it.

This cliff section was described by Mr. Whitaker in his Memoir on Sheet 48 S.E., published in 1877, the first Geological Survey Memoir in which the Crag was dealt with.

The next section visited was at Beaumont, five and a half miles west of Walton cliff (see map, p. 441, also p. 439). It is a small pit showing 5 feet of current-bedded ferruginous sand with a few pebbles, and abundant shells and shell-fragments.

The third section was at Little Oakley, the locality numbered 5 on the map, p. 441; there was merely a small digging in a field, but Mr. Harmer had obtained a splendid series of fossils from it (see p. 439), and he had most kindly prepared a quantity of sifted material from which the party were able to collect with much greater ease than they would have done from the section. In the end, I think all who wished were able to obtain a fine series of specimens.

The party returned to Ipswich by boat from Harwich.

TUESDAY, JULY 29TH.

The sections visited were as follows:—

1. Sutton.—A pit about five furlongs south-east of the church; a very fine section some 15 feet deep; current-bedded Red Crag in places full of shells. The top, to a depth of three feet or so, was decalcified, and the shells gone.

2. Sutton.—A pit about five furlongs south-west of Wood Hall. This is I believe the celebrated "Bullock Yard" pit originally noticed by Lyell, and described by Prestwich. It is marked D on his sketch-map.‡ I think we walked from "Farm House" down "Occupation Road" to 'Cottage" and visited a working somewhere between the points marked "D" and "Summit" on Prestwich's map. Formerly the Red Crag was seen here lying up against an island of Coralline Crag (see p. 444, fig. 74) and a figure of the old shore line is given by Prestwich.§

The junction was not exposed at the time of our visit, but

* Memoir on Sheet 48 S.E. 1877. p. 13.
† *Quart. Journ. Geol Soc.*, vol. lvi, p. 712 (1900).
‡ *Quart. Journ. Geol. Soc.* vol. xxvii. Plate vi. (1871).
§ *Quart. Journ. Geol. Soc.* vol. xxvii, p 340, fig. 21 (1871) reproduced by Mr. Whitaker "Geol. of Ipswich," Mem. on Sheets 48 N.W. and 48 N.E., p. 68, fig. 15.

the Coralline Crag with an abundance of fossils was seen at one part of this pit and the Red Crag, also fossiliferous, in another part close by.

3. Shottisham Hall.—A small pit in Red Crag full of shells close to the farm.

The Red Crag of the above three sections is classed by Mr. Harmer as belonging to the Newbournian Stage.

4. Alderton.—A large section in current-bedded sand and ferruginous grit with some pebbles. Shells abundant.*

5. Bawdsey Cliff.—Fine section in Red Crag on London Clay. The junction between the two was not well seen, but Mr. Whitaker found it in one place.† The Red Crag of localities 4 and 5 is classed by Mr. Harmer as Butleyan (see p. 442 and map, p. 432). The section at Bawdsey was visited by kind permission of Sir Cuthbert Quilter, Bart., M.P.

During the day the President proposed a vote of thanks to Mr. F. Woolnough, Curator of the Ipswich Museum, for his kind assistance during the excursion.

In the evening Miss Layard brought a series of very fine flint implements, which she has recently found near Ipswich, for exhibition, and her kindness was much appreciated by the members.

WEDNESDAY, JULY 30TH.

The following sections were visited :—

1. Sand-pit east of Wilford Bridge (N.E. of Woodbridge), showing buff and reddish sand, current-bedded throughout, with ferruginous layers, and concretions, the whole reminding one of the Folkestone Beds of the Lower Greensand. There was a thin bed of flint and quartz pebbles about half way up the section. Mr. Harmer considered this sand to belong to the Middle Glacial Series (see p. 458), and to be of marine origin.

2. Butley.—Fine section in current-bedded Red Crag (Butleyan Stage), upper part decalcified, but lower part full of shells. The beds are ferruginous with ironstone layers in places, and there are phosphatic pebbles in fair numbers.

3. Butley Neutral Farm Pit.—Another section in Red Crag of same stage.

4. Chillesford.—We visited the pit behind the church, of which a section is given by Prestwich.‡ At the top there are a few feet of Chalky Boulder Clay, our first view of the formation of which we were subsequently to see and hear a great deal. Below is the Chillesford Clay, fossiliferous, and below that a bed of sand

* Section given by Mr. Whitaker, "Geol. of Ipswich," p. 67.
† See Whitaker, *op. cit.*, p. 69.
‡ *Quart. Journ. Geol. Soc.*, vol. xxvii, p. 336, fig. 18, and see Dalton, Mem. on Sheets 49 and 50 S.E., p. 18.

described by Prestwich as without shells. It is, however, full of casts of shells, and an interesting series has been collected by Mr. Harmer (see p. 447). We had not time to visit the lower pit in the Stackyard, which is in Red Crag of the Butleyan Stage according to Mr. Harmer (see note, p. 447).

5. Sudbourne.—Pit 14 on map, p. 426. Coralline Crag decalcified (see p. 424), with many Pectens and Polyzoa. It is current-bedded throughout, and Mr. Harmer suggested 10 fathoms as probably the maximum depth of the sea in which this Crag was deposited.

6. Sudbourne.—Pit 18. Similar section; the current-bedding on rather a larger scale.

7. High House Farm.—Pit 19. The upper part of the pit is in Red Crag, full of shells. At a lower level the Coralline Crag is seen in the same pit.

8. Sudbourne Park.—Pit 12 on map, p. 426. Coralline Crag, current-bedded, full of shells, *Cardita senilis* specially abundant. Some fine valves of *Cyprina islandica* were obtained (see p. 425).

Tea was provided at the Castle Hotel, Orford, and after tea the President proposed votes of thanks to Sir Cuthbert and Lady Quilter, and to Mr. A. H. C. Wood, of Sudbourne Park, for permission to visit sections on their estates, and to Miss Layard and Miss Outram for the trouble they had taken in bringing and exhibiting the flint implements alluded to above.

THURSDAY, JULY 31ST.

The members travelled by rail from Ipswich to Forncett Junction and drove by way of Wymondham to Norwich (Royal Hotel).

A section in Chalky Boulder Clay on the railway from Forncett Junction to Wymondham was first visited. The Clay contained a good many chalk fragments and also large flints which had not been at all rolled or waterworn. Blocks of shale, probably Kimeridgian, and stones which appear to be of Carboniferous rock are common. Mr. Harmer said that the chalk was a hard variety from Lincolnshire, and he believed that this clay was brought by a glacier which approached East Anglia from the north-west (see p. 465).

The second section visited was a large pit at Tharston Furze Hill—probably the same as that figured by Mr. H. B. Woodward in his Memoir on the country around Norwich (plate iii, fig. 10, and see pages 69, 70).

I noticed below his bed 5, consisting of coarse flint gravel, an irregular bed of pebbles nearly all flint, though quartz pebbles more than an inch in diameter occur. This pebble bed lies in patches cutting down into the Crag Beds, 3 of Mr. Woodward's section. Unfortunately, I did not find any Chalky Boulder Clay as he did, and consequently I cannot say what its relation to the pebble beds may be, but I suspect it is newer and that the pebbles are either Middle Glacial or Westleton or Crag—probably Westleton.

Lines of pebbles also occur in the Crag of Mr. Woodward's bed 2.

The third section was a large gravel pit at Wymondham which Mr. Harmer explained to be of later age than the Chalky Boulder Clay (see p. 471). The gravel shows very little sign of stratification and consists to a great extent of large stones. I noted rounded flints, boulders of sandstone, of shale, of quartz, and of several varieties of igneous rock. It has been termed Cannon-shot gravel. I brought away a fragment of a boulder of dark-coloured igneous rock, probably diabase, showing spheroidal weathering.

Fourthly, a small section in Chalky Boulder Clay was seen at Hethersett, after which, the members drove to Mr. Harmer's residence at Cringleford and were most hospitably entertained at tea by Mrs. Harmer.

After tea a portion of Mr. Harmer's splendid collection of Crag fossils was inspected, and the large collection from the very small working at Oakley (see p. 439) was greatly admired.

FRIDAY, AUGUST 1ST.

This day was devoted to an examination of the cliff-section between Happisburg, or Hasboro', and Trimingham. At Hasboro' the Cromer Till was very well seen and fragments of shells were easily found in it (see pp. 452-453). Mr. Harmer is of opinion that the Till came from the north or north-west, and he considers that the fragments of marine shells in it show that the ice to which it is due approached Norfolk from the sea. In that case the shells are not "derived" from older fossil beds, but are the shells living or lying dead in the sea at the time of its formation.

For further details of the Hasboro' section see Mr. Reid's memoir ("Cromer," p. 88, fig. 8).

The valley deposit at Mundesley described in Lyell's "Antiquity of Man" (4th edition, 1873, p. 268, fig. 37) was found to be almost hidden by modern improvements. Some sections in the Forest Bed were noticed and the celebrated Chalk bluff at Trimingham attracted much attention. A photograph of it has already been reproduced in our Proceedings (vol. xiii, p. 61, see also Reid, "Cromer," p. 116, fig. 13).

The party ascended the cliff at Trimingham and were most hospitably entertained at tea by Mrs. and Miss Ford.

SATURDAY, AUGUST 2ND.

On this day the cliff between Kessingland and Pakefield was examined. The Chalky Boulder Clay is very well shown for a considerable distance. A much larger proportion of the boulders, large and small, as well as pebbles, are of chalk at this place than at Forncett Junction. Boulders of rock other than chalk are, however, not by any means uncommon. Most of the boulders are striated.

The Boulder Clay rests upon current-bedded sand, and the bottom of the clay is a very even and nearly horizontal plane. In one place I noticed, below the Boulder Clay, 1½ feet of sand with chalk pebbles and a few flints; at the bottom of which there was a ferruginous layer and then below it current-bedded sand. This last is believed to be Middle Glacial, for in the Corton Cliff north of Lowestoft a similar sand is underlain by a Lower Boulder Clay.

As Pakefield is approached, the current-bedded sands become pebbly in places, and there is a good deal of current-bedded pebbly sand near the foot of the cliff. Mr. J. H. Blake drew a line through this current-bedded series, and whilst he allowed the upper or more sandy part to be Glacial, he left the lower or more pebbly part in an indeterminate position between the Glacial and the Pliocene.

Proceeding along the shore to Pakefield, we found that the sea had exposed a fine section at that place. The current-bedded series becomes more and more pebbly, until at the end of Pakefield Street, below the Cliff Hotel, the top of the cliff is found to be more pebbly than the bottom, the section being:—

1. Earth and surface	2 feet.
2. Current-bedded pebbly sand	10 to 15 feet.
3. Current-bedded sand, few pebbles ...	...Considerable thickness.
4. Fairly evenly stratified sand with very little current-bedding	12 feet.

Mr. Whitaker thought bed 4 was probably Crag.

At the foot of the cliff, between Kessingland and Pakefield, are some undoubted Pliocene Beds— Forest Bed and Chillesford Clay; they are fully described in the late Mr. J. H. Blake's Memoir on Yarmouth, etc. (1890. *Geol. Survey*).

Note by Mr. W. W. Whitaker.—The section seen here seems new. Mr. Blake's engraved cliff-section ends at this spot, and it is clear that he never saw anything like what we did, or he would have recorded it.

The pebbly gravel, which is a mere nothing near the base of the cliff to the south, rises up northward (from below the Glacial sand, etc.) in a sweeping curve, and at the same time increases greatly in thickness, so that at last it forms, roughly, the upper half of the cliff. It dovetails sharply into the underlying sand in a southerly direction. It seems to me that we have here the pebbly gravel of Westleton, etc., and that the sand beneath may be Crag, much as in parts of the Dunwich cliff.

In this case the pebbly gravel ties on to the sand below, and not to that above; to the Crag rather than to the Glacial Drift. But I regret not having been able to make a more lengthy examination.

I have said that Mr. Blake divided the current-bedded series. Mr. H. B. Woodward,* however, considers it to be all of Middle Glacial age, and he draws attention to the similarity of the pebbly part to the Westleton Shingle of Westleton Common—suggesting, if I understand him rightly, that the beds at Westleton Common are Middle Glacial too.

However this may be, it is clear that the mere presence or absence of pebbles is no reason for drawing a dividing line, for the current-bedded sand is in places clearly inter-bedded with pebble-beds, and south of Pakefield lighthouse we get the upper part of the bed sandy and the lower part pebbly, whilst in the section given above the reverse is the case.

On the succeeding day most of the members visited the Castle at Norwich. Until quite recently it was used as a prison, but the Corporation have now fitted it up as a Museum, and their very fine collections are admirably displayed there. The Curator, Mr. Reeve, and the Assistant-Curator, Mr. Leney, very kindly showed the members over the galleries.

I was more especially interested with the collection of Middle Glacial shells alluded to on pp. 459-460. Most of the larger species are fragmentary, but the small shells are often well preserved, and I should certainly say afford some evidence that the bed in which they were found is of marine origin.

MONDAY, AUGUST 4TH.

The cliff between Weybourne and Cromer was examined. It is fully described in Mr. Clement Reid's Memoir on Cromer, and in the Report of our last Excursion (*Proc. Geol. Assoc.*, vol. xiii, 1893-4, p. 64).

The large mass of marl in the cliff between Beeston and West Runton (Reid, "Cromer," p. 102) attracted attention; it was noticed to pass downwards into an ordinary boulder clay, and the lowest part was seen to be well laminated, probably owing to movement at the time of deposition.

There was a good deal of discussion as to the great boulders of chalk in the Contorted Drift, and as to the origin of the contortions. Mr. Reid's views will be found in the "Geology of Cromer," p. 116; Mr. Harmer's have been given at p. 456. There appears to be a general impression that they are due, directly or indirectly, to Scandinavian ice. Possibly this may be so, but I have never myself been convinced that

* *Geol. Mag.*, N.S., Dec. IV., vol. ix, pp. 27-30, 1902.

land-ice crossed the deep channel which runs along the coast of Norway; in fact, I do not believe any Norwegian land-ice has ever travelled, as land-ice, so far as England. Norwegian geologists are, however, inclined to think that a great elevation of something like 8,000 ft. took place in the north during the period of maximum glaciation. It is possible that this elevation did not seriously affect south-east England, and that consequently there was a tendency for both water and ice to flow southwards, and this would account for many things.

During the afternoon the President proposed votes of thanks to Mr. Whitaker and to Mr. Harmer, the Directors of the Excursion; to Mrs. Harmer, for her hospitality on July 31, and to Mrs. and Miss Ford, for their hospitality on August 1; to Mr. E. P. Ridley, for acting as Excursion Secretary during the whole Excursion; to Mr. Reeve, the Curator of the Norwich Museum, and to Mr. Leney, the Assistant-Curator, for their kindness on the occasion of the visit of the members to the Museum.—H. W. M.

(By E. W. Skeats.)

TUESDAY, AUGUST 5TH.

A start was made from the hotel at 9.30 a.m. The village of Thorpe being first visited, Mr. Harmer gave reasons for his opinion that the valley along which the party travelled was not post-Glacial, but owed its origin to the excavating power of land ice during Glacial times. Evidence in favour of this view was seen in a new road cutting near the lunatic asylum at Thorpe, where Chalky Boulder Clay was noticed as a valley deposit about the level of the 20 feet contour line. By the movement of the ice down the valley the Crag beds had been much disturbed, the Boulder Clay in places cutting through them, so that it rested directly on the Chalk.

The next section visited was the famous Norwich Crag pit, at Thorpe, the highest part of which is about the level of the 50 feet contour line. The upper fifteen feet consists of gravels, probably the local representatives of the Westleton Pebble Beds. The base of these gravels for about three feet is much impregnated with iron oxide, due to the holding up of surface water by a band of clayey loam, three feet thick, which possibly represents the Chillesford Clay. Beneath this the Norwich Crag was noticed as a bed of white sand about eight feet thick, containing badly preserved shells. The "Stone Bed" one foot in thickness was seen below the Norwich Crag, resting evenly on the horizontal surface of the Chalk. Quite at the top of the pit was an interesting deposit of dark-coloured slag, and it was observed that at the base of the slag the earth was burnt and discoloured for a depth of several inches. Mr. Whitaker, who drew attention to this occurrence, thinks that it had not been previously noticed.

At a short distance north of this section, but near the 100 feet contour line, another pit was visited. Here the oldest beds exposed were Lower Glacial Sands, probably corresponding in age to the Westleton Beds. Above these came the Norwich brick-earth (also Lower Glacial), while the Middle Glacial Sands rested upon the brick-earth and continued to the top of the pit. It was noticed, however, that at the northern end of the pit, the Norwich brick-earth had been forced over the Middle Glacial Sands and appeared to rest upon them. Mr. Harmer expressed the opinion that this local disturbance was also due to the movement of land ice down the valley already referred to. The local character of the disturbance was shown by the fact that at a slightly higher level a section was seen in which the Middle Glacial Sands were exposed at the surface, and the underlying beds occurred in their normal positions.

Immediately opposite, on the south or Whittingham bank of the valley, here about three-quarters of a mile wide, the position of the quarry was pointed out, where the great disturbance, shown in Mr. Harmer's paper (p. 471, fig. 80), was formerly to be seen, while midway within the valley, just above the level of the Alluvium, Chalky Boulder Clay rests on the glaciated surface of the Chalk. The relations existing between these various sections is well illustrated by a diagram on page 469 of the same paper.

The party then returned towards Norwich, where they found time to make a hasty inspection of the series of sections in the sharply cut side of the Wensum valley immediately to the north of the city, showing the local geological succession from the Chalk to the Middle Glacial Sands. Overlying the latter are the well known "Cannon-shot" gravels of Mousehold Heath, of similar age and character to those visited at Wymondham a few days before. They form a plateau, at an elevation of about 150 feet above the river, and extend quite to the lip of the valley. In Mr. Harmer's opinion they were due to violent floods during the melting of the ice at the close of the Chalky Boulder Clay period. Such floods could not have occurred under the conditions now obtaining, and therefore the gravel must either be older than the excavation of the valleys, or at the time of their deposition the latter must have been filled with ice. The gravels are undoubtedly of later origin than the Chalky Boulder Clay, however, and as that deposit exists within the valleys, extending to an unknown depth below O.D., we seem to be driven to the latter conclusion.—E. W. S.

EXCURSION TO THE S.E.R. MAIN LINE WIDENING AT ELMSTEAD CUTTING.

SATURDAY, OCTOBER 4TH, 1902.

Directors: T. V. HOLMES, F.G.S., AND C. W. OSMAN, A.M.I.C.E.

(*Report by* C. W. OSMAN.)

THE object of this excursion was to make a further examination of the Elmstead cutting, which was only partly opened out at the Association's visit on April 26th last.

The party met at Grove Park Station and walked over the top of Chiselhurst Tunnel to Elmstead cutting. This fine exposure can now be well seen from the end of the new tunnel to the termination of the cutting, a distance of about eighteen chains. The condition of the cutting was very favourable for examination, as the removal of a portion of the old tunnel to afford room for the new Elmstead Station made a series of terraces which enabled the members to examine the section at all heights.

The true bedding of the sands is much obscured by the high dip of the false bedding to the east, but the following succession dipping at an angle of about three degrees to the north could be fairly made out.

	ft.	in.
False bedded sand and shingle with many beds of hard conglomerate, varying in thickness from 6 inches to 2 feet. Top not seen	40	0
White sand	6	6
Pebble band, rocky in places	8	0
Pebbles in green sand	1	0
Slightly clayey green sand (seen)	5	0

Mr. Whitaker states that the bottom bed is the basement bed of the Woolwich and Reading Series, and as the low cutting just to the south is in Thanet Sand this is doubtless correct.

At Marble Lane Bridge at the north end of the tunnel the Woolwich shell beds and clays are well developed. They were also found in a boring in the new tunnel, 200 yards from the north end (about 16 feet in thickness), but are altogether absent at Elmstead cutting, the Oldhaven beds resting directly on the basement bed of the Woolwich Series, so that the clays and shell beds are completely cut out in a distance of less than half a mile.

In the false bedded sands and conglomerates, besides an abundance of shells, a large number of remains of pieces of wood were found, and also in the conglomerates some cavities lined with dark brown crystals. The cutting being adjacent to the well-known Sundridge Rock Pit, a reference to the very full list of fossils in Vol. IV, Memoirs of the Geological Survey, will be sufficient.

ORDINARY MEETING.

FRIDAY, JUNE 6TH, 1902.

H. W. MONCKTON, F.L.S., F.G.S., President, in the Chair.

W. Burghard and J. W. Purkis were elected members of the Association.

The following papers were read:

"On a Peculiarity in the Course of Certain Streams in the London and Hampshire Basins," by H. J. OSBORNE WHITE, F.G.S.

"Note on the Occurrence of Microtus intermedius in the Pleistocene Deposits of the Thames Valley," by MARTIN A. C. HINTON and GILBERT WHITE.

After which the REV. J. F. BLAKE gave a short account of the geological features to be observed during the excursion to Headington, Shotover, and Wheatley on June 7th.

Mr. J. FRANCIS exhibited some specimens of Tentaculites from the Lower Devonian of Bois Roux, Brittany.

The SECRETARY exhibited, on behalf of Mr. T. P. Moody, a series of specimens of Amberite and Coal from Hikurangi, New Zealand.

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Mr. W. WHITAKER gave a short account of the work of the Geological Survey in East Anglia, after which a paper was read by Mr. F. W. HARMER, F.G.S., entitled "A Sketch of the Later Tertiary History of the Eastern Portion of East Anglia." The paper was well illustrated by diagrams and lantern slides.

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C. GILBERT CULLIS, D.Sc., F.G.S.

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